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FLOWER BEHAVIOR OF AVOCADO VARIETIES

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THREE TEXT FIGURES

The avocado is said to have been introduced into the Philippines from Mexico as early as 1890. However, its successful introduction dates back only about twenty-nine years ago from Hawaii, Costa Rica and the United States. The growing of the avocado is a promising commercial venture in the Islands. Its fruit is finding a ready sale in the market and fetches a better price than that of other fruits because of its high fat-food value. There are now avocado trees growing in widely separated localities in the Philippines and the behavior of these trees clearly indicates that the plant is at home in this country. It was only lately, however, that the avocado has been planted on a more or less commercial scale.

It has been reported that the avocado varieties now growing in the Islands fruit indifferently. Opinion seems to be unanimous that many avocado varieties fail to bear fruit satisfactorily owing to a lack of pollination brought about by the failure of the flower to open at the proper time, or to incompatibility of the pollen itself. In the Philippines no study has so far been reported as regards the flower behavior of the avocado or its failure to bear fruit from this point of view. But Nirody(1), Stout(2), Robinson and Savage(3), Van Elden(4), and Ryerson(5) have obtained results showing that even though the avocado flowers profusely under favorable soil and climatic con-

ditions and with proper cultural treatment, it may fail to produce fruits or, in the event of setting, the fruits may drop off prematurely due to the fact that its flowers tend to open in unison. Each flower opens and closes for two distinct periods at different times during its cycle; one set is receptive while the other is shedding its pollen. During the first opening the pistil is almost always receptive but no pollen is shed, and during the second opening the pollen is shed but by this time the pistil is usually past the receptive stage. Self-incompatibility exists in some avocado varieties and in a few varieties a considerable overlapping between the two periods of opening occurs, thus making possible a very limited self-pollination. Such overlapping is sometimes affected by weather conditions. As pointed out by Stout(2), variable weather conditions, particularly abrupt changes in illumination, temperature, humidity and wind exposure, cause marked changes in the rather precise periodicity of flower opening during clear, warm, bright weather. These changes result in the increase of the amount and prolongation of overlapping, frequently increasing the opportunity for self-pollination many fold. The fruiting of isolated trees in some localities and occasionally by solid-blocks of well-known varieties might be due to this according to Ryerson(5). Thus the more satisfactory setting of fruits of some varieties where atmospheric conditions are subject to both continual and frequent sudden changes is partially explained in all probability by this increased overlapping. For this reason, the interplanting of avocado varieties having flowers opening at different times has been recommended so as to produce the best result. In the Philippines the avocado has been and is still being planted without taking into consideration its flower behavior so that now we find many handsome and vigorously growing trees that either fail to bear fruit or if they do, only very sparingly.

Stout(2), Robinson and Savage(3), and Ryerson(5) believe that fruit setting in avocado will be more successful if compatible varieties are interplanted whose flowers open at such time that will permit cross-pollination, or if self-compatible varieties are discovered, the opening periods of whose flowers overlap. According to these authors, until we find self-compatible varieties, the mixed planting of two or more varieties of avocado has necessarily to be followed in laying out an orchard of this tree in order to obtain the best possible results. Stout and Robin-

son and Savage have grouped the avocado varieties into two; namely, Group A and Group B, each group shedding pollen at different times. The avocado orchard planning, therefore, as recommended by these authors should include varieties of both the A and the B group, each shedding pollen at such a time as to coincide with open flowers in a receptive mode on the other reciprocating variety. Furthermore, the varieties to be chosen should have approximately the same or at least an overlapping flowering season; early bloomers of the A group, for example, are unsuited for planting with distinctly late bloomers of the B group. The midseason bloomers would serve both for planting with early or late varieties, since the flowering season of the avocado usually lasts several weeks. The lack of compatibility between varieties may still interpose difficulties, but the mixed planting at least immeasurably increases the chances for effective pollination, as compared with solid planting of one variety or of varieties all having the same periodicity of bloom. It is for this reason that the present observations of the flowering habits of the avocado varieties at the Lamao Horticultural Station, Lamao, Bataan; Tanauan Citrus Experiment Station, Tanauan, Batangas; Lipa, Taal, Talisay, and Mataas-na-kahoy, Batangas; San Fernando and Mexico, Pampanga; Calumpit, Bulacan; Indang, Cavite; and in Los Baños, Laguna, have been undertaken during the 1933–34 and 1934–35 flowering seasons of the avocado.

MATERIALS AND METHODS

All the varieties either budded, grafted or seedling trees that have so far fruited at the Lamao Horticultural Station and at the Tanauan Citrus Experiment Station, and several privately owned trees in Lipa, Taal, Talisay and Mataas-na-kahoy, Batangas; San Fernando and Mexico, Pampanga; Calumpit, Bulacan; Indang, Cavite; and in Los Baños, Laguna, were observed as regards their flowering habits. The main observation was conducted in Lamao, however. In Lamao flowers of 22 trees consisting of 18 named and 4 unnamed avocado varieties were studied; in Batangas (Tanauan, Lipa, Taal, Talisay and Mataas-na-kahoy) 40 named and 151 trees of unnamed varieties; in Pampanga (San Fernando and Mexico) 12 unnamed trees; in Bulacan (Calumpit) 1 named and 2 unnamed trees; in Cavite (Indang) 1 named and 30 unnamed trees; and in Laguna (Los Baños) 2 named and 46 unnamed trees, thus making a total of

307 trees. Records of the closing and opening of from 63 to 852 avocado florets of each tree, or a total of 61,286 florets from different panicles were taken during the two flowering seasons—January to May, 1934, and November, 1934 to April, 1935. A preliminary study of the flowers was first made as a guide in determining the important parts and characters of the flowers opening during the first and second periods. Before the appearance of the flower buds or while the flowers were still in the bud stage, the general characteristics of the flower buds were compared with those of the leaf buds, originating both from the terminal and lateral twigs. The place of origin of the flower buds were also determined. In Lamao several flowering shoots whose flowers were about to open were marked and labelled. Daily observations lasting from early in the morning till late in the afternoon were taken of the opening, receptiveness of the stigma, and closing of the first period flowers on the different trees. The time of opening and closing, including the shedding of the pollen in the second opening period, were recorded together with the weather conditions. To find the cause of the setting of fruits of some isolated trees in the 1935 flowering season, the number and percentage of fresh stigmas or those appearing receptive during the latter opening period were noted. In other places the same procedure was followed but the observations of the flowers from each tree were performed only once for a day or so. This short time observation was considered accurate enough for this study since the flowers of an avocado variety behave in the same way and the flowers which opened for the first time can be easily distinguished from the flowers that opened for the second time.

To determine the number of flowers borne on each terminal as well as on the lateral shoots, a count of the individual flowers in a panicle of fifty twigs each of two varieties of avocado in Lamao was made. Descriptions of the flower buds which were about to open and those that had opened for the first time were made from trees in Lamao, Lipa, Tanauan and Mataas-na-kahoy during the 1934 flowering season. Similarly during the two flowering seasons, the extent of the defoliation accompanying the formation of flowers of the Lamao avocados was noted.

In accordance with the foregoing observations, the avocado varieties studied were grouped or classified as to the manner of defoliation, flower opening, and the corresponding graphs were drawn for the opening of the flowers.

DISCUSSION OF RESULTS

The flower and the leaf buds of the avocado varieties in Lamao began to appear as early as August, while the flower panicles from these flower buds developed during the dry season—from November to May—or when the trees were in their dormant condition. An overgrown stock plant (unnamed variety) of avocado flowered the earliest and the Cyrus the latest. In the 1933–34 flowering season, it took 64 days for the flower buds of the Family variety to develop fully into panicles and 147 days for the Cyrus and Pollock; while in the 1934–35 flowering season 21 days for the Commodore and 83 days for the Tumin. The length of time it takes for the flower panicle to develop from its first appearance as a flower bud apparently depends much on the health of the tree and partly on the weather conditions. The time of flowering depends much upon the vigor of the trees and to the soil and climatic conditions. Table 1 gives the flowering period of the avocado varieties in Lamao.

TABLE 1.—*Showing the flowering time of the avocado varieties at Lamao, Bataan*

Variety	Budded, grafted, or seedling	1933–1934				
		Date of appearance of—			Number of days from—	
		Flower bud	Flower panicle	Last appearance of flower	Bud to panicle	Panicle to last appearance of flower
Quality	B	9– 5–33	1–11–34	3–25–34	128	73
Unnamed	S	8– 1–33	11–15–34	3– 1–34	106	106
Avocado No. 1	S	9– 9–33	1– 4–34	3– 1–34	117	56
Wester	B	10– 1–33	1–25–34	3–25–34	116	59
Family	G	12– 1–33	2– 3–34	3– 5–34	64	30
Dickinson	B	11– 5–33	2–12–34	3–30–34	99	46
Lyon	B	12–10–33	3–10–34	4–20–34	90	41
Cyrus	S	10–10–33	2–25–34	5–10–34	147	74
Cyrus	S	2–12–34	5– 3–34	6– 4–34	80	32
Cyrus	B	10– 1–33	2–20–34	4–25–34	142	64
Commodore	B	12– 1–33	3–10–34	5– 1–34	99	52
La Carlota No. 7	G	9– 1–33	1–25–34	2–29–34	147	36
Avocado No. 5	S	10– 1–33	1–15–34	2–20–34	106	36
Pollock	B	10– 1–33	2– 5–34	4–15–34	127	69
Pollock	S	10– 1–33	2–25–34	4–30–34	147	64
Tumin	B	12– 1–33	3– 8–34	4–15–34	97	38
Cardinal	B	11–10–33	3– 8–34	5–10–34	118	63
Cardinal	B	11– 5–33	1– 8–34	4–14–34	123	37
Waldin	B	12–10–33	3–10–34	4–20–34	90	41
Vega	B	9– 5–33	1–11–34	4–14–34	128	93
Cummins	B	12– 5–33	3–10–34	5–15–34	95	36

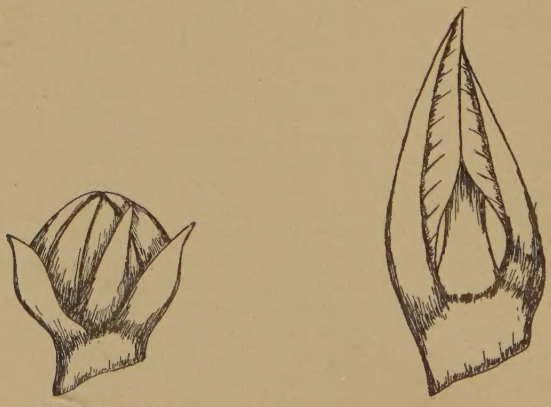
TABLE 1.—*Showing the following time, etc.*—Continued.

Variety	Budded, grafted, or seedling	1934–1935				
		Date of appearance of—			Number of days from—	
		Flower bud	Flower panicle	Last appearance of flower	Bud to panicle	Panicle to last appearance of flower
Quality	B	12-20-34	2- 3-35	3- 5-35	45	30
Unnamed	S	9-20-34	11- 3-34	1-10-35	44	68
Avocado No. 1	S	11-30-34	1-10-35	2-28-35	41	48
Wester	B	11-30-34	1- 9-35	3-25-35	40	75
Family	G	[a]	[a]	[a]	[a]	[a]
Dickinson	B	[b]	[b]	[b]	[b]	[b]
Lyon	B	12-20-34	1-20-35	3- 8-35	31	47
Cyrus	S	11-30-34	12-25-34	3-10-35	25	75
Cyrus	S	1-20-35	2-20-35	3-20-35	31	28
Cyrus	B	12-20-34	2-20-35	2-25-35	62	33
Commodore	B	1-25-35	2-15-35	3-15-35	21	28
La Carlota No. 7	G	10- 5-34	12- 8-34	1- 2-35	64	25
Avocado No. 5	S	10- 7-34	11-25-34	2-13-35	79	80
Pollock	B	10- 1-34	11-25-34	1-15-35	55	51
Pollock	S	11- 7-34	1- 2-35	3- 8-35	57	65
Tumin	B	11-25-34	2-15-35	3-12-35	83	25
Cardinal	B	1-20-35	2-23-35	3-30-35	34	35
Cardinal	B	1- 9-35	2-20-35	3-30-35	42	38
Waldin	B	[a]	[a]	[a]	[a]	[a]
Vega	B	8-28-34	10-20-34	3-10-35	53	140
Cummins	B	11-25-34	2- 2-35	----------	69	----------

[a] Did not flower in 1935 [b] Blown down by the storm in 1935

NOTE.—B stands for budded plants, S for seedlings, and G for grated plants

When the scales and transition leaves of an avocado bud develop very slowly, it indicates that the bud is going to be a flower bud. The flower bud is somewhat more rounded in shape



(*a*) Flower bud (*b*) Leaf bud

FIG. 1. Buds of Wester avocado.

than the leaf bud as shown in text fig. 1 (*a*) and measures from 3 to 5 mm. long and 2 to 4 mm. across. On the other hand, the leaf bud as shown in text fig. 1 (*b*) is pointed and the scales are normal in size and grow faster than those of the flower

FIG. 2. Flower clusters produced from the trunk of La Carlota No. 2 avocado topworked on Dickinson

buds. The avocado trees generally flower at the end or tip of the shoots or at the axil of the leaves near the tip of the previous season's growth. However, in a few instances flower panicles are developed from the big branches as in text fig. 2. The flower panicles produced at the tip of the shoots were usually more vigorous and branched more freely than those panicles

originating elsewhere on the tree. Almost all twigs of heavy bearing trees flowered.

The flowering of the avocado is generally accompanied by either heavy or light defoliation depending upon the variety and the quantity of flowers produced, and this leaf fall is immediately followed by the development of new leaves. Still other varieties flower without changing their leaves.

Trees which flowered heavily in 1934, as in the case of the Unnamed Tree, Lyon, Commodore, Cardinal, Vega and Cummins shed their leaves heavily. On the other hand, only slight defoliation occurred during the flowering season in 1935 on trees which produced but few flowers such as the Quality, Lyon, Cyrus, Commodore, Pollock, Cardinal, Vega and Cummins. The natural tendency of a bearing twig in almost all varieties of avocado is to defoliate its leaves at or previous to flowering and then superseded immediately with the development of new leaves to support the fruits. Consequently, a heavy flowering tree would defoliate heavily, and the opposite would occur on trees with few flowers.

TABLE 2.—*Showing the leaf fall of avocado varieties at Lamao, Bataan*

Variety	Budded, grafted, or seedling	Defoliation of leaves						Quantity of flowers	
		1934			1935				
		Heavy	Light	None	Heavy	Light	None	1934	1835
Quality	B	—	X	—	—	X	—	Light	Light.
Unnamed	S	X	—	—	X	—	—	Heavy	Heavy.
Avocado No. 1	S	X	—	—	—	—	X	Heavy	Very light.
Wester	B	—	X	—	—	X	—	Heavy	Heavy.
Family	G	—	—	X	—	—	—	Light	None.
Dickinson	B	—	X	—	—	—	—	Light	None.
Lyon	B	X	—	—	—	X	—	Heavy	Light.
Cyrus	B	—	—	X	—	—	X	Light	Light.
Cyrus	S	—	X	—	—	X	—	Light	Light.
Commodore	B	X	—	—	—	X	—	Heavy	Light.
La Carlota No. 7	G	X	—	—	X	—	—	Heavy	Heavy.
Avocado No. 5	S	X	—	—	X	—	—	Heavy	Heavy.
Pollock	B	X	—	—	X	—	—	Heavy	Heavy.
Pollock	S	—	X	—	—	X	—	Light	Light.
Tumin	B	X	—	—	X	—	—	Heavy	Heavy.
Cardinal	B	—	X	—	—	X	—	Light	Light.
Cardinal	B	X	—	—	—	X	—	Heavy	Light.
Waldin	B	—	X	—	—	—	—	Light	None.
Vega	B	X	—	—	—	X	—	Heavy	Light.
Cummins	B	X	—	—	—	X	—	Heavy	Light.

NOTE.—B stands for budded plants, S for seedlings, and G for grafted plants

The extent of defoliation of other varieties of avocado sometimes varies with the different trees of the same variety. For instance, a tree of the Cardinal variety defoliated heavily while another tree of the same variety defoliated lightly only; some trees of the Pollock and Cyrus varieties behaved similarly. This may be accounted for partly by the influence of the stock plant used, since the seedling trees of these varieties behaved uniformly as regards their leaf fall.

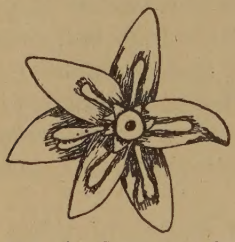
The avocado flower is small and perfect and is characterized by the entire absence of sepals and with rather scarce pollen. The stigma is small and slightly curved to pointed tip, bright greenish-canary in color, watery and sticky at the receptive stage. It varies in size depending upon the variety and vigor of the tree—9–13 mm. in diameter; petals 6–8, and from 3–7 mm. long and 2–3 mm. broad; stamens 3–4 in number in the first layer and 6–8 in the second, and 3–4 mm. long and 0.5–1 mm. wide; anther, 0.9–2 mm. long and 0.5–1.5 mm. wide; ovaries, 1–2.5 mm. long and 0.9–1.5 mm. in diameter; nectaries, 0.9–2 mm. long and 0.8–1.5 mm. wide. .

The flower bud is oval to rounded in shape and when about to open is either light apple-green, greenish-canary, or light green and when fully developed it is either canary, greenish-canary, apple-canary, or light green. (Standard Dictionary, Twentieth Century Edition, was used for the color guide.)

The count made of the total number of flowers from 100 panicles gave an average of 162.9 flowers per terminal panicle and 203.5 for the panicle produced on the lateral twigs. An over-grown stock plant had fifty of its terminal twigs bearing more flowers than the lateral twigs or 7,111 individual flowers against 4,389, while Avocado No. 1 had fifty lateral twigs bearing 15,993 individual flowers against 9,188 of the terminal. Therefore, based on the average number of flowers per twig, the former produced 142 for the terminal and 87 for the lateral twigs, while in the latter there were 183 for the terminal and 319 for the lateral twigs. However, the peduncles of the terminal twigs are more stocky and larger than those of the lateral twigs. A full-grown bearing avocado tree produces thousands upon thousands of flowers so that if out of these flowers even a fraction of one per cent will develop into fruits an abundant crop may be expected.

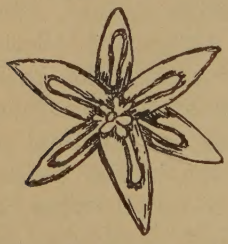
Behavior of the flower.—The flowers of avocado in general have two distinct periods of opening and closing during their life cycle. It took 34 hours for the flower of the Group A varie-

ties to complete its cycle (from first opening to its final closing) and only 24 hours for the Group B varieties. The period during which a flower is again closed, that is, between the first and second periods of opening is longer in the former group than in the latter or 23 against 11 hours. As the flowers are produced successively, consequently the first opening of some flowers coincides with the second opening of other flowers every day during the flowering season. On the first opening the flowers with all the stamens, nectaries and corolla are on a flat plane and the ovary with its stigma is well exposed which indicates that it is ready to receive the pollen, as shown in text fig. 3 (*a*) and (*b*). A few minutes after the first opening of the



(*a*) Top view of a flower open for the first time

(*b*) Side view of the same flower open for the first time



(*c*) Top view of a flower open for the second time

(*d*) Side view of the same flower open for the second time

FIG. 3. Various stages of flowers of Cyrus avocado

flower the stigma becomes receptive and remains in this condition until the flower closes for the first time. The same flower reopens on the following day when the pollen is shed but the stigma in most cases is no longer capable of receiving the pollen because it is already in a constricted condition and of a brownish color and sometimes has the sign of rottening at the tip. At this time the small white sacks of the anther bearing the pollen extend outside the openings of the anther on the two sides ready to discharge their contents. The stigma is in general lower than the first layer of stamens which are standing closely side by side with it so that even if it is receptive the chances of pollina-

tion by insects is rather remote. At this stage the corolla are hanging in outward direction and the first layer of stamens are standing close to the pistil while the second layer of stamens and all nectaries are in a slanting position as shown in text fig. 3 (*b*).

Avocado varieties whose flowers open for the first time in the morning will reopen in the afternoon of the following day, while varieties whose flowers open for the first time in the afternon will again open the next morning. This periodicity of flower opening is found to be a fixed character of the varieties, and thus far no proved exceptions have been found under normal weather conditions according to Robinson and Savage(3). In our study, however, we found a tree owned by Mr. P. Whitaker of San Fernando, Pampanga, the flowers of which opened only once. In the majority of cases the flowers of this particular tree opened from 7:05 to 8:10 a. m. and began closing from 11 a. m. to 9:15 p. m. Still other flowers remained open till night time. This unusual and long opening period of the flowers was not due to the variance in climatic conditions as pointed out by Stout(?) since the weather during the three days of our observations of the flowers of the tree in question was rather uniform. Furthermore, there are no findings so far reported that the sudden change of the weather, as for instance, from bright to either cloudy, shower, or rain, may omit one of the opening periods of any avocado flowers. The effects of weather on the opening and closing of avocado flowers are presented in Table 3 and the corresponding graph.

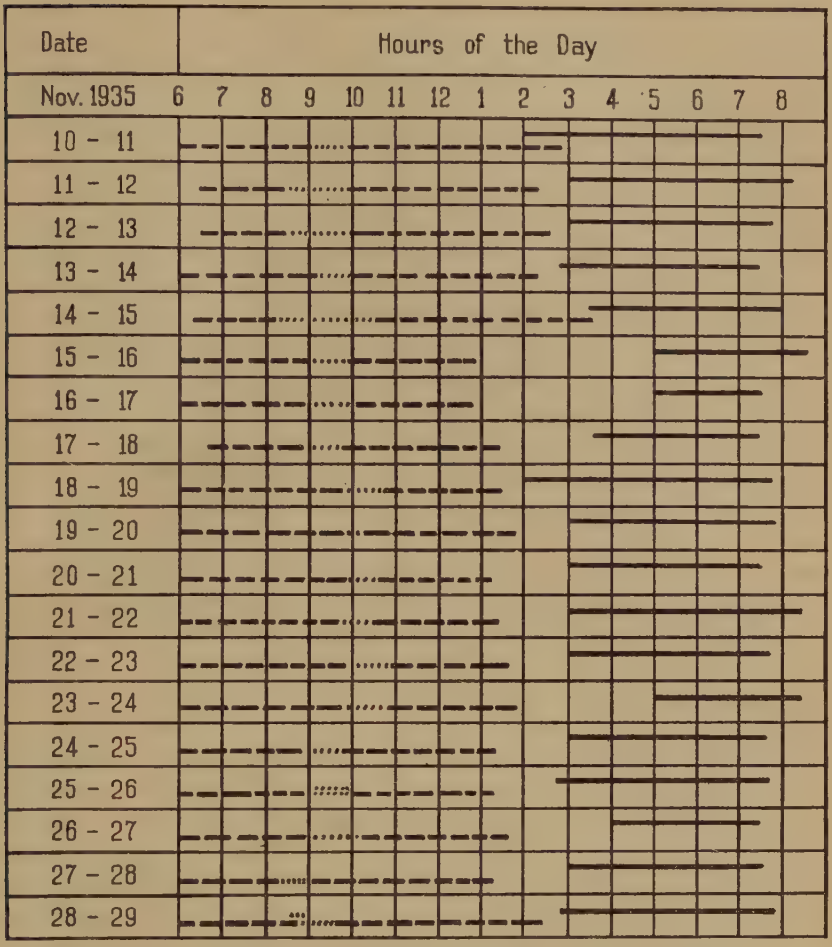
As shown in Graph I cloudiness or rain has very little influence on the time of opening and closing; it retarded a little the first opening and closing period on November 14–15 and 28–29, respectively. On the other hand, on November 10–11, 11–12, and 12–13 when the weather was bright, the opening and closing were also variable. In connection with the effect of weather, observations were also made on the behavior of the flowers under different temperatures. The results are given in Table 4.

As shown in Table 4, a higher temperature preceding the opening of the flowers hastened the time of opening as on November 17–18, 19–20, and 20–21; while a lower temperature retarded it as on November 18–19 and 21–22.

As the receptiveness of the stigma and dehiscence of pollen of the same flower of an avocado variety occur at different periods practically no pollination takes place or if at all, very

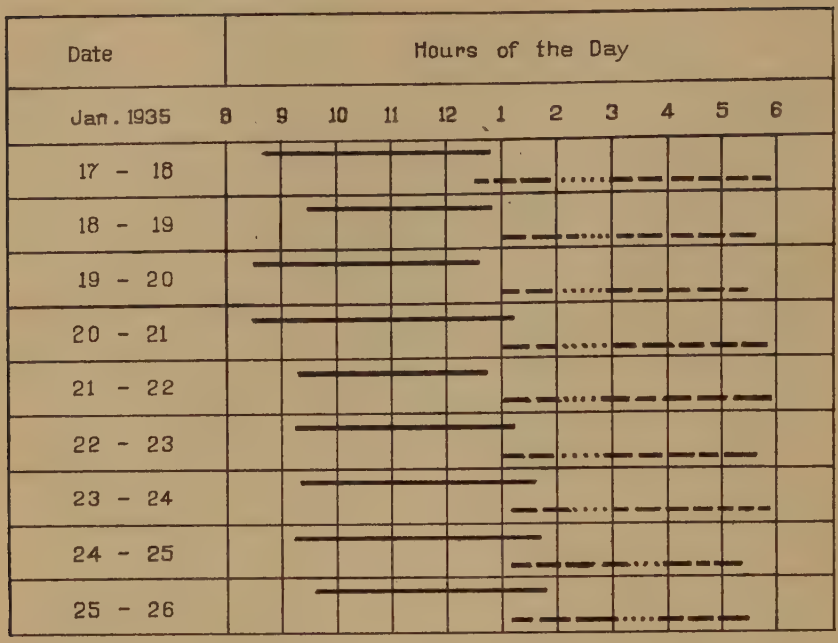
TABLE 3.—*Showing the first and second periods of opening and closing of flowers of Vega avocado as influenced by the weather conditions*

Date of observation November 1935	Number of flowers observed	First opening period p. m.			Second opening period a. m.			Weather	
		Time of—							
		Opening	Receptiveness of stigma	Closing	Opening	Pollen Dehiscence	Closing	A. M.	P. M.
10–11	66	2:00–5:15	2:05–5:20	7:00–7:45	6:00–7:59	9:15–9:50	1:00–2:55	Bright	Bright.
11–12	82	3:00–5:15	3:05–5:20	8:00–8:10	6:30–7:59	8:40–9:50	1:00–2:20	Bright	Bright.
12–13	99	3:00–4:59	3:05–5:02	7:00–7:55	6:25–7:59	8:40–9:50	12:40–2:45	Bright	Bright.
13–14	127	2:50–5:20	2:55–5:25	7:00–7:30	6:00–7:59	9:15–9:59	12:30–2:20	Partly cloudy and bright	Cloudy.
14–15	113	3:30–4:59	3:35–5:03	7:20–7:59	6:25–7:40	8:20–10:20	2:00– 3:40	Rainy and windy	Rainy and windy.
15–16	243	5:00–5:30	5:05–5:35	8:00–8:30	6:00–7:59	9:00– 9:59	12:00–12:55	Cloudy, rainy and windy	Cloudy, rainy and windy.
16–17	215	5:00–6:30	5:05–5:35	7:00–7:20	6:00–7:40	9:00– 9:59	12:00–12:55	Partly cloudy and bright	Partly bright, cloudy and rainy.
17–18	311	3:45–4:55	3:50–5:00	7:00–7:30	6:35–7:10	9:00– 9:30	11:00– 1:30	Partly cloudy and bright	Bright.
18–19	371	2:00–4:59	2:05–5:03	7:00–7:55	6:00–7:00	10:00–10:20	12:00– 1:45	Partly bright and cloudy	Bright.
19–20	137	3:00–4:30	3:05–4:35	7:00–7:50	6:00–7:30	10:00–10:05	1:00– 1:50	Bright	Bright.
20–21	192	3:00–4:20	3:05–4:25	7:00–7:35	6:00–7:15	10:00–10:15	1:00– 1:25	Bright, partly cloudy and shower.	Rainy and cloudy.
21–22	134	3:00–5:10	3:05–5:15	8:00–8:10	6:00–7:06	10:00–10:10	12:00– 1:30	Bright	Bright and partly cloudy.
22–23	127	3:00–5:25	3:05–5:30	7:00–7:40	6:00–6:40	10:00–10:45	1:00– 1:45	Cloudy and partly bright	Cloudy and rainy.
23–24	151	5:00–7:10	5:05–7:15	8:00–8:20	6:00–7:15	10:00–10:30	10:00– 1:55	Cloudy and partly bright	Cloudy and rainy.
24–25	163	3:00–4:35	3:05–4:40	7:00–7:35	6:00–6:45	9:00– 9:30	1:00– 1:25	Bright	Partly cloudy and bright.
25–26	228	2:50–4:59	2:55–5:03	7:00–7:40	6:00–6:50	9:00– 9:50	1:00– 1:25	Bright	Bright and partly cloudy
26–27	156	4:00–4:30	4:04–4:33	7:00–7:25	6:00–6:45	9:00–10:05	1:00– 1:30	Bright	Bright.
27–28	103	3:00–4:10	3:05–4:15	7:00–7:30	6:00–6:40	8:30– 8:50	1:00– 1:25	Bright	Bright and partly cloudy.
28–29	151	2:50–4:59	2:54–5:03	7:00–7:40	6:00–6:40	8:40– 9:20	1:30– 2:30	Cloudy and showering	Cloudy with shower.



GRAPH I. Showing the flower behaviors of Vega avocado as influenced by the weather conditions.

slight. Because of these intervening periods of flower opening of the avocado, only very few flowers are capable of reciprocating each other. Pollen is shed only on the second opening of the flower, at which time most of the stigmas were usually past the receptive stage. Since varietal compatibilities are seldom found to exist among the commercial varieties cultivated, the only chance of pollinating the stigma by insects—insects are the chief agents of pollinating the avocado flowers for a successful fruit production—is to have an overlapping of the receptiveness of the stigmas of some varieties during the first opening period with the period of dehiscence of pollen of other varieties. This



GRAPH II. Showing the flower behaviors of the unnamed stock for Dickson avocado as influenced by the daily temperature.

may be accomplished in three ways, viz., (1) by interplanting varieties in which the receptiveness of their stigmas coincides with the dehiscence of pollen of other varieties, provided insects and bees are present to effect pollination from trees to trees; (2) by topworking a portion of the trees with one or more reciprocating varieties in an already established orchard composing of one variety or varieties of one group provided the varieties to be topworked have approximately the same vigor and flowering period with the topworked trees; and (3) by planting avocado seedlings. This system of planting may result in the production of trees belonging to both the A and B groups thus facilitating cross-pollination. However, the planting of vegetatively grown plants is more desirable for the reason that asexually grown trees in most cases come true to type.

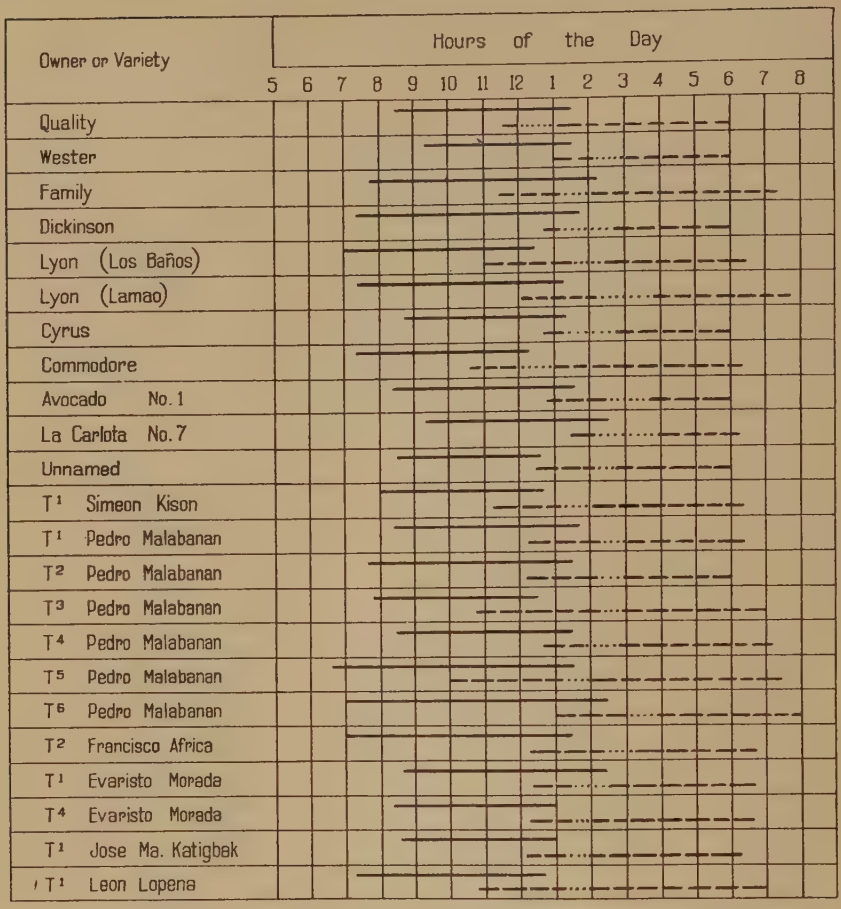
As already stated elsewhere Robinson and Savage(3) and Stout(2) have grouped the avocado varieties into two—the A and B groups. Group A are the varieties whose flowers open for the first time in the morning and dehisce their pollen in the afternoon of the following day, and Group B are the varieties whose flowers open for the first time in the afternoon and dehisce their pollen the next morning as indicated in Graphs III and IV drawn

TABLE 4.—*Showing the first and second periods of opening and closing of the flowers of an unidentified variety of avocado as influenced by temperature*

Date of observation January 1935	Number of flowers observed	First opening period A. M.		
		Time of—		
		Opening	Receptiveness of stigma	Closing
17–18	398	8:45– 9:59	8:50–10:03	12:15–12:59
18–19	290	9:25–10:30	9:30–10:35	12:00–12:59
19–20	381	8:30– 9:30	8:35– 9:35	11:35–12:40
20–21	529	8:40– 9:45	8:45– 9:50	12:00– 1:10
21–22	274	9:15– 9:30	9:20– 9:35	12:40–12:50
22–23	417	9:35–10:50	9:40–10:55	1:00– 1:25
23–24	291	9:30– 9:50	9:35– 9:55	1:15– 1:45
24–25	354	9:20– 9:50	9:25– 9:55	1:30– 1:50
25–26	279	9:40– 9:50	9:45– 9:55	1:15– 1:55

Date of observation January 1935	Number of flowers observed	Second opening period P. M.		
		Time of—		
		Opening	Pollen dehiscence	Closing
17–18	398	12:30–1:59	2:00–2:50	4:40–5:50
18–19	290	1:00–1:30	2:35–2:59	4:40–5:40
19–20	381	1:00–1:45	2:00–2:38	5:00–5:30
20–21	529	1:00–1:59	2:00–2:50	5:10–5:50
21–22	274	1:00–1:15	2:00–2:45	5:15–5:55
22–23	417	1:00–1:20	2:00–2:50	5:15–5:40
23–24	291	1:15–1:30	2:15–2:50	5:30–5:50
24–25	354	1:10–1:40	3:30–3:50	5:15–5:45
25–26	279	1:15–1:45	3:30–3:40	5:15–5:48

Date of observation January 1935	Number of flowers observed	Temperature in Centigrade					
		A. M. (8–11)			P. M. (12–5)		
		Minimum	Maximum	Average	Minimum	Maximum	Average
17–18	398	24.0	26.4	25.37	27.0	31.0	25.26
18–19	290	23.2	27.0	24.87	25.5	29.2	27.95
19–20	381	24.5	27.0	26.05	24.5	27.5	25.81
20–21	529	23.6	27.0	25.35	26.0	28.9	27.90
21–22	274	22.5	28.0	24.87	24.0	28.0	26.00
22–23	417	21.0	26.5	23.50	25.0	28.9	25.36
23–24	291	22.0	28.5	25.92	25.2	26.0	25.36
24–25	354	23.5	26.0	24.92	26.5	29.0	27.63
25–26	279	24.8	27.6	26.72	26.8	27.8	27.16

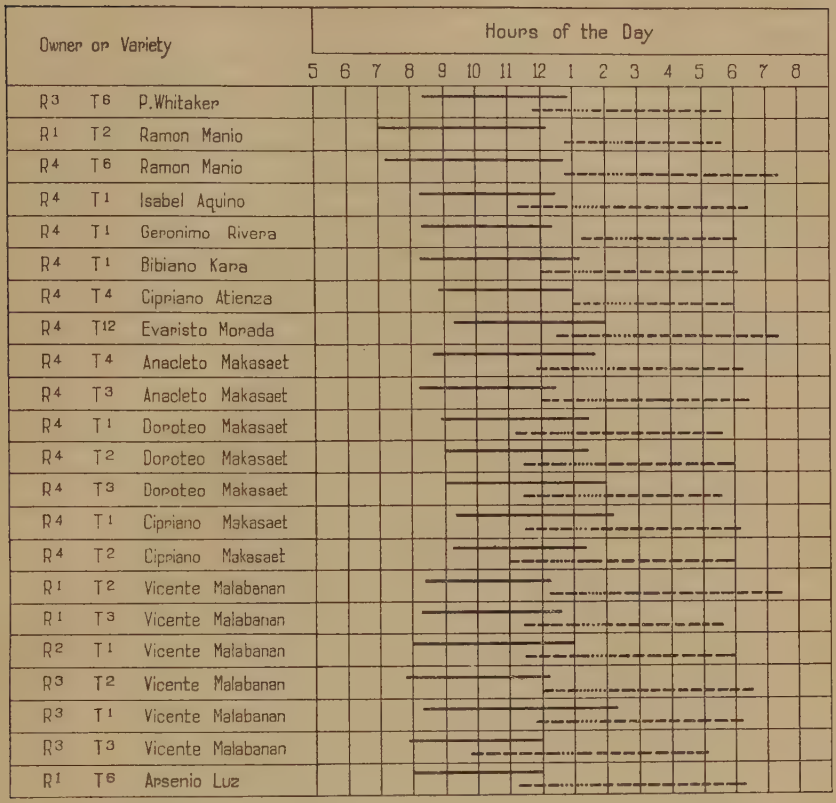


GRAPH III (*a*). Showing the flower behavior of avocado varieties under Group A.

from hourly observations which tables being too long were purposely omitted.

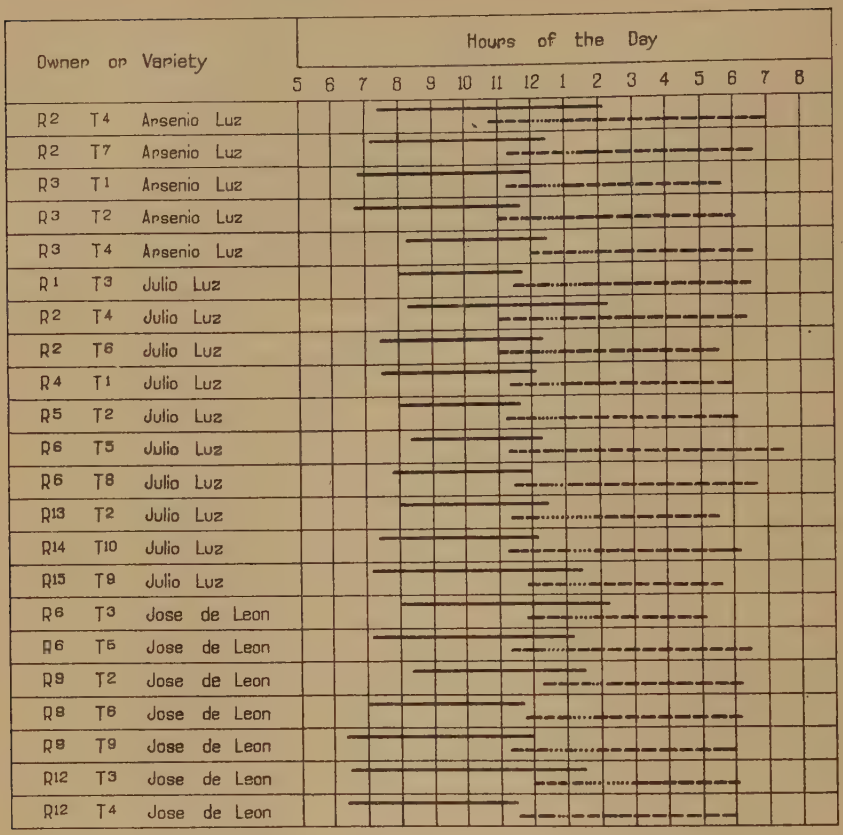
In these graphs the solid lines indicate the first opening periods of the flowers of the different varieties of avocado when the stigmas are receptive, and the second opening periods, by the broken lines while the dots between the broken lines when the pollen started to dehisce.

The time of the dehiscence of pollen and the receptiveness of the stigma varied according to the varieties. In 1934, the duration from opening to closing of the flowers of the avocado varieties under Group A in Lamao and in Batangas ranged from 2 hours and 50 minutes to 7 hours and 30 minutes for the first opening period and from 4 to 8 hours and 30 minutes for the


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R3 T6 P.Whitaker
R1 T2 Ramon Manio
R4 T6 Ramon Manio
R4 T1 Isabel Aquino
R4 T1 Geronimo Rivera
R4 T1 Bibiano Kara
R4 T4 Cipriano Atienza
R4 T12 Evaristo Morada
R4 T4 Anacleto Makasaet
R4 T3 Anacleto Makasaet
R4 T1 Doroteo Makasaet
R4 T2 Doroteo Makasaet
R4 T3 Doroteo Makasaet
R4 T1 Cipriano Makasaet
R4 T2 Cipriano Makasaet
R1 T2 Vicente Malabanan
R1 T3 Vicente Malabanan
R2 T1 Vicente Malabanan
R3 T2 Vicente Malabanan
R3 T1 Vicente Malabanan
R3 T3 Vicente Malabanan
R1 T6 Arsenio Luz

GRAPH III (*b*). Showing the flower behavior of avocado varieties under Group A.

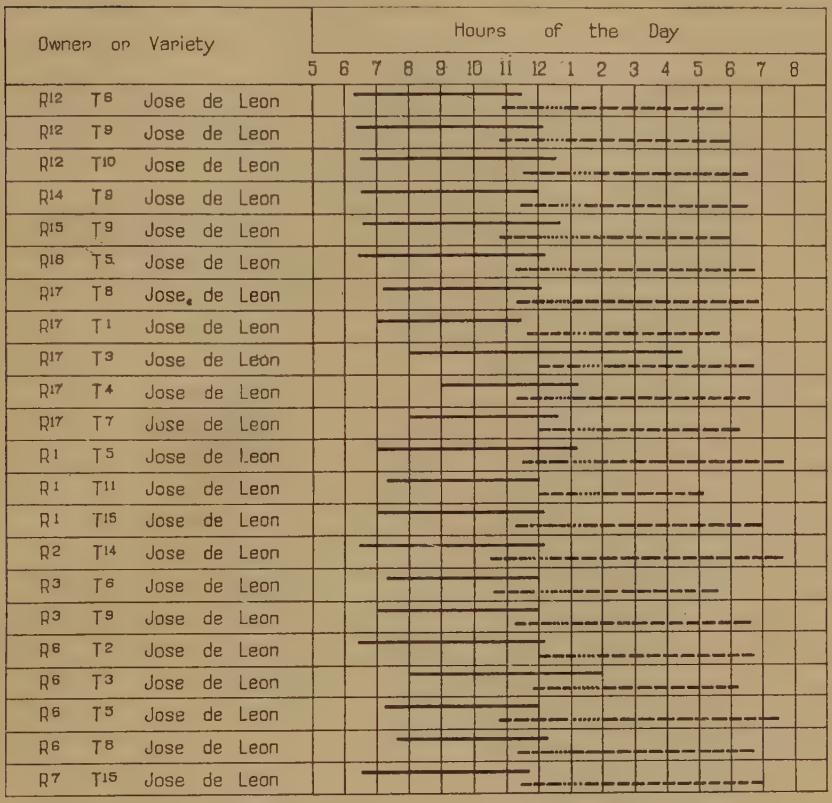
second period. In 1935, it ranged from 2 hours and 10 minutes to 6 hours and 50 minutes and from 4 hours and 30 minutes to 9 hours and 20 minutes. The stigma became receptive in 2 to 10 minutes and remained receptive until the closing of the first opening period of the flower. The dehiscence of the pollen took place from ½ to 3 hours and 50 minutes during the second opening of the flower. The interval from the first opening to the second period ranged from 20 hours and 50 minutes to 26 hours and 40 minutes, while the varieties under Group B the duration was from 1 hour and 30 minutes to 7 hours and 8 minutes for the first opening, 2 hours and 45 minutes to 14 hours and 10 minutes for the second period. The stigma is receptive in 2 to 10 minutes and the dehiscence of pollen from 35 minutes to 3 hours and 25 minutes. The interval of the first to the second opening range from 7 hours and 15 minutes to 16 hours.


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R2 T4 Arsenio Luz
R2 T7 Arsenio Luz
R3 T1 Arsenio Luz
R3 T2 Arsenio Luz
R3 T4 Arsenio Luz
R1 T3 Julio Luz
R2 T4 Julio Luz
R2 T6 Julio Luz
R4 T1 Julio Luz
R5 T2 Julio Luz
R6 T5 Julio Luz
R6 T8 Julio Luz
R13 T2 Julio Luz
R14 T10 Julio Luz
R15 T8 Julio Luz
R6 T3 Jose de Leon
R6 T5 Jose de Leon
R9 T2 Jose de Leon
R8 T6 Jose de Leon
R9 T9 Jose de Leon
R12 T3 Jose de Leon
R12 T4 Jose de Leon

GRAPH III (*c*). Showing the flower behavior of avocado varieties under Group A.

The pollen of the varieties in Groups A and B remained fresh from the time of dehiscence up to 5 and 12, respectively, and at which time most of the pollen have already been carried away by insects. At the second opening the stigmas of some of the trees in Groups A and B appeared to be still receptive, while the stigmas of other trees were no longer fresh as shown on Tables 5 and 6.

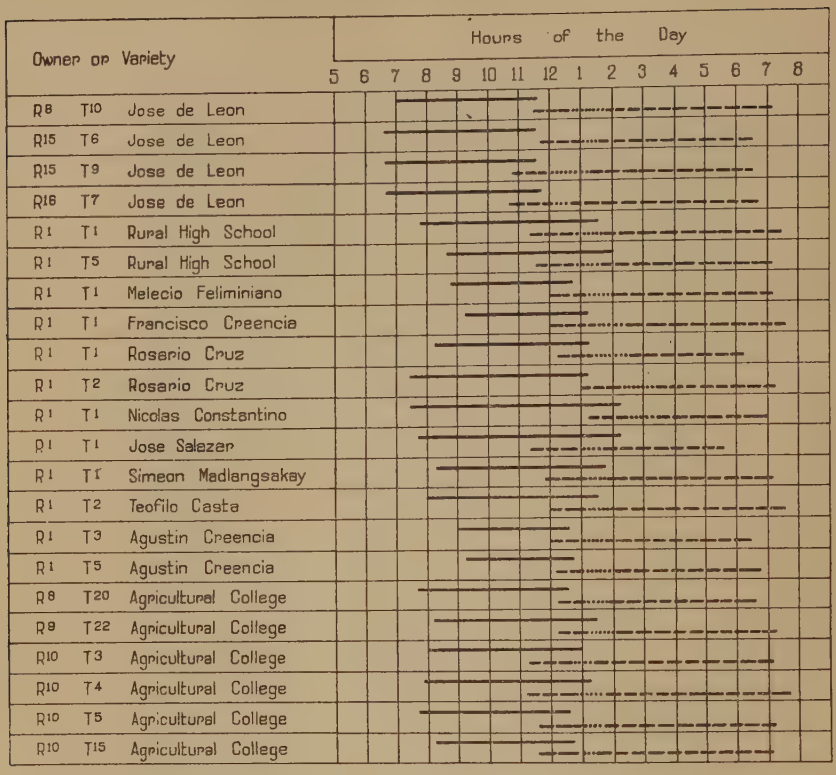
In Group B there were more trees with fresh stigmas during the second opening period of the flowers than in Group A or 78 against 50. This may be due to the fact that in Group A the flowers of the avocado suffer more from the heat of the sun than the flowers in Group B since their first opening period is in the morning, while the flowers of the avocado in Group B first open in the afternoon. The percentage of the fresh stigmas varies on different trees—from 0.52 to 26.52 per cent for Group A and from 0.36 to 20.80 per cent for Group B.


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R12 T6 Jose de Leon
R12 T9 Jose de Leon
R12 T10 Jose de Leon
R14 T9 Jose de Leon
R15 T9 Jose de Leon
R18 T5 Jose de Leon
R17 T8 Jose de Leon
R17 T1 Jose de Leon
R17 T3 Jose de Leon
R17 T4 Jose de Leon
R17 T7 Jose de Leon
R1 T5 Jose de Leon
R1 T11 Jose de Leon
R1 T15 Jose de Leon
R2 T14 Jose de Leon
R3 T6 Jose de Leon
R3 T9 Jose de Leon
R6 T2 Jose de Leon
R6 T3 Jose de Leon
R6 T5 Jose de Leon
R6 T8 Jose de Leon
R7 T15 Jose de Leon

GRAPH III (*d*). Showing the flower behavior of avocado varieties under Group A.

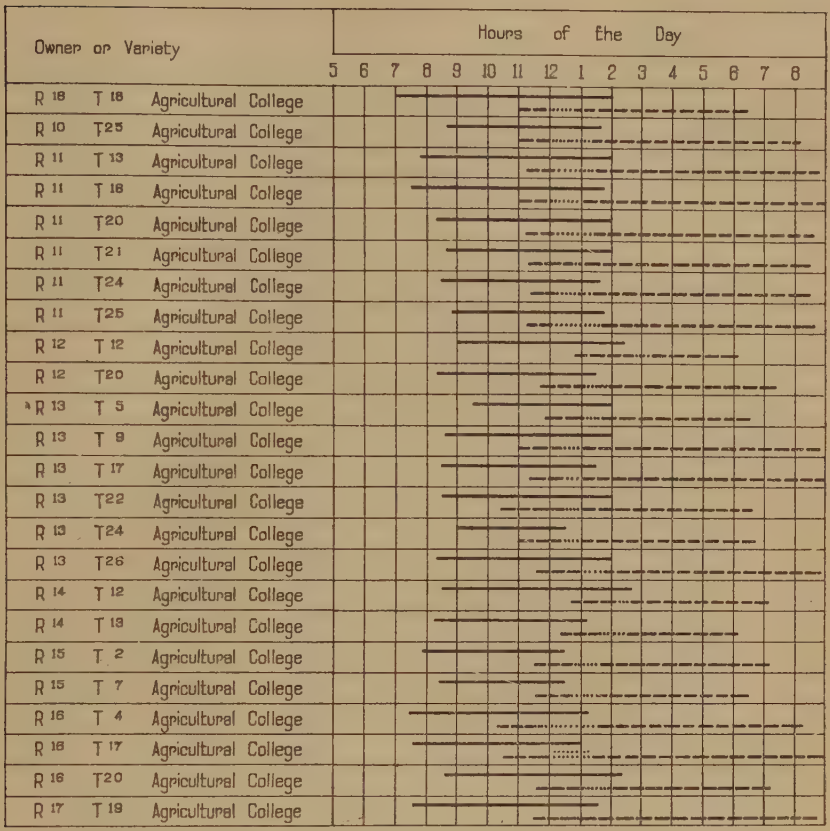
The production of fruits of isolated trees where there is no possible cross-pollination with other varieties or overlapping of the opening periods is undoubtedly due to the freshness and receptiveness of the stigmas and the nondehiscence of pollen during the second opening period of the flowers. Under such condition, however, the fruits produced in each of the flower panicles were fewer in number than on trees where cross-pollination or overlapping of the opening periods occurred.

Observations of the flower behaviors of the different avocado varieties were taken during the months of November, January, February, March, April and May. Of the varieties in Group A the Quality, Family, Commodore, Lyon in Los Baños, Dickinson, La Carlota No. 7 and 53 unnamed varieties had the receptiveness of their stigmas overlapped with the dehiscence of their pollen—in short, they are self-compatible varieties. Fifty-seven trees of this group have their first and second openings overlapped but that the receptiveness of their stigmas and the dehis-


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R8 T10 Jose de Leon
R15 T6 Jose de Leon
R15 T9 Jose de Leon
R16 T7 Jose de Leon
R1 T1 Rural High School
R1 T5 Rural High School
R1 T1 Melecio Feliminiano
R1 T1 Francisco Creencia
R1 T1 Rosario Cruz
R1 T2 Rosario Cruz
R1 T1 Nicolas Constantino
R1 T1 Jose Salazar
R1 T1 Simeon Madlangsakay
R1 T2 Teofilo Casta
R1 T3 Agustin Creencia
R1 T5 Agustin Creencia
R8 T20 Agricultural College
R9 T22 Agricultural College
R10 T3 Agricultural College
R10 T4 Agricultural College
R10 T5 Agricultural College
R10 T15 Agricultural College

GRAPH III (*e*). Showing the flower behavior of avocado varieties under Group A.

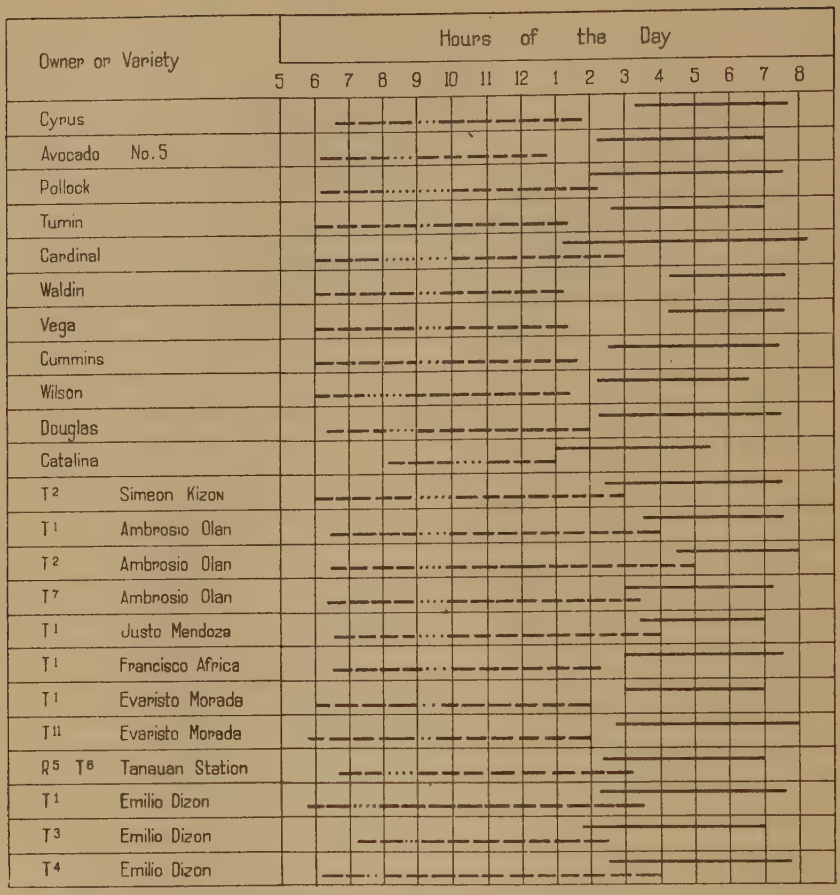
cence of their pollen do not coincide and 12 trees exhibited no overlapping whasoever. In Group B no self-compatible varities were found. However, the first and second opening periods overlapped on 57 trees, and no overlapping whatsoever on 67 trees. One of the controlling factors for the successful setting of fruits of avocados is the overlappings of the two opening periods of the flowers of a given variety or tree in which the receptiveness of the stigma and the dehiscence of pollen coincide. But although the two periods may overlap yet no fruits would set if the flowers that opened for the first time would close before the dehiscence of pollen during the second opening as for instance in the case of Avocado No. 1, Wester, Cyrus and Unnamed variety. However, of the self-compatible varieties just mentioned the flowers that opened for the second time will be capable of pollinating the incoming flowers in the same tree whose first opening coincides with the former and so on. No overlapping whatsoever has occurred on the Lyon and Com-


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R 18 T 18 Agricultural College
R 10 T25 Agricultural College
R 11 T 13 Agricultural College
R 11 T 18 Agricultural College
R 11 T20 Agricultural College
R 11 T21 Agricultural College
R 11 T24 Agricultural College
R 11 T25 Agricultural College
R 12 T 12 Agricultural College
R 12 T20 Agricultural College
R 13 T 5 Agricultural College
R 13 T 9 Agricultural College
R 13 T 17 Agricultural College
R 13 T22 Agricultural College
R 13 T24 Agricultural College
R 13 T26 Agricultural College
R 14 T 12 Agricultural College
R 14 T 13 Agricultural College
R 15 T 2 Agricultural College
R 15 T 7 Agricultural College
R 16 T 4 Agricultural College
R 16 T 17 Agricultural College
R 16 T20 Agricultural College
R 17 T 19 Agricultural College

GRAPH III (*f*). Showing the flower behavior of avocado varieties under Group A.

modore varieties. In this group, varieties with late closing of the first opening period can be interplanted with the early pollen dehiscence varieties such as the Quality with the Avocado No. 1, Wester, Family, Dickinson, Cyrus, or La Carlota No. 7. The flowers of the Dickinson opened two hours earlier than those of La Carlota No. 7 and therefore there was some chances for the first-period flowers of the late La Carlota No. 7 to be pollinated by the flowers of the earlier Dickinson avocado. The flowers of Avocado No. 5 opened two hours earlier than the Vega variety.

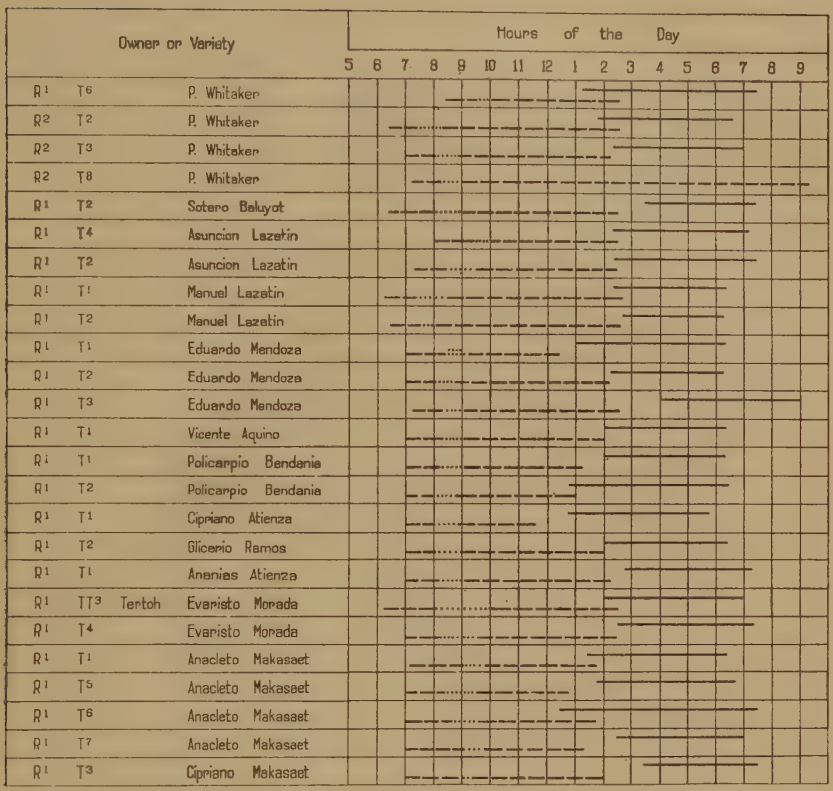
Of the best avocado varieties so far examined the Family, Lyon and the Wester of Group A should be interplanted with the Cardinal and Pollock of Group B. In the latter group no overlapping of the two opening periods occurs and therefore any variety planted in this group should necessarily be mixed with one or more varieties belonging to Group A.



GRAPH IV (*a*). Showing the flower behavior of avocado varieties under Group B.

Robinson and Savage and Stout have placed the Dickinson, the Wester, and the Family avocados under Group A, and the Lyon, Cardinal, Tumin, Waldin and Pollock under Group B.

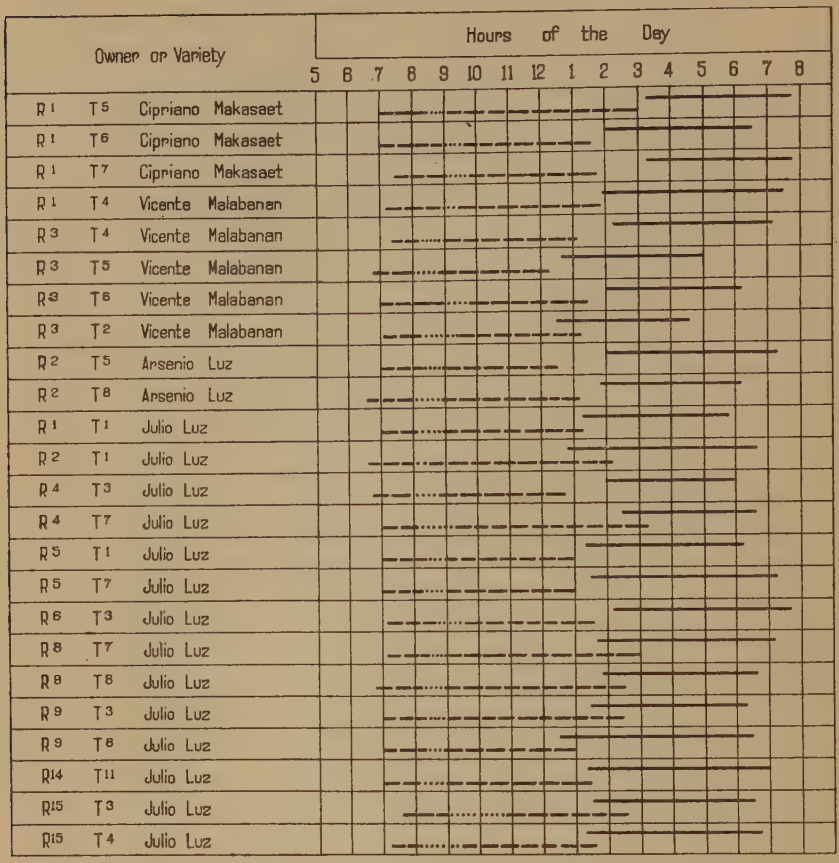
As regards the named varieties found fruiting in Batangas province and in Lamao, Bataan, both budded and seedling trees, as for example, the Lyon behaved differently. The Lyon although it falls under Group A yet in Lamao it falls under class two while in Tanauan in class three. Moreover, budded trees behaved differently too. A budded tree of the Pollock and a seedling tree of the Cardinal fall under Group B of class 2 and two budded plants of Pollock and Cardinal and a Cardinal seedling fall under class one of Group B. These different flower behaviors of the same variety may be either due to the environ-


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9
R1 T6 P. Whitaker
R2 T2 P. Whitaker
R2 T3 P. Whitaker
R2 T8 P. Whitaker
R1 T2 Sotero Baluyot
R1 T4 Asuncion Lazatin
R1 T2 Asuncion Lazatin
R1 T1 Manuel Lazatin
R1 T2 Manuel Lazatin
R1 T1 Eduardo Mendoza
R1 T2 Eduardo Mendoza
R1 T3 Eduardo Mendoza
R1 T1 Vicente Aquino
R1 T1 Policarpio Bendania
R1 T2 Policarpio Bendania
R1 T1 Cipriano Atienza
R1 T2 Glicerio Ramos
R1 T1 Ananias Atienza
R1 TT3 Tertoh Evaristo Morada
R1 T4 Evaristo Morada
R1 T1 Anacleto Makasaet
R1 T5 Anacleto Makasaet
R1 T6 Anacleto Makasaet
R1 T7 Anacleto Makasaet
R1 T3 Cipriano Makasaet

GRAPH IV (*b*). Showing the flower behavior of avocado varieties under Group B.

mental factors or to the variations resulting from planting seedlings, or to the influence of the stock itself.

The different varieties in a group when propagated asexually have maintained their class flower behavior even under different soil and climatic conditions as for instance, the Cardinal and Pollock of Group B, and Lyon and Family of Group A. These varieties have behaved in the same way in Lamao and in Batangas. On the other hand, the seedlings and the budded plants of the Cyrus avocado even under the same conditions have behaved differently—the seedling trees fall under Groups A and B and the budded plants under Group B. This is also true in the case of Commodore where the budded plant falls under Group A while the seedling tree under Group B. Generally speaking, however, the weather conditions during the course of these observations were rather uniform except when the flowers of the Cummins avocado were under study, the weather was then rather cloudy and with intervening showers. Such a


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R 1 T 5 Cipriano Makasaet
R 1 T 6 Cipriano Makasaet
R 1 T 7 Cipriano Makasaet
R 1 T 4 Vicente Malabanan
R 3 T 4 Vicente Malabanan
R 3 T 5 Vicente Malabanan
R 3 T 6 Vicente Malabanan
R 3 T 2 Vicente Malabanan
R 2 T 5 Arsenio Luz
R 2 T 8 Arsenio Luz
R 1 T 1 Julio Luz
R 2 T 1 Julio Luz
R 4 T 3 Julio Luz
R 4 T 7 Julio Luz
R 5 T 1 Julio Luz
R 5 T 7 Julio Luz
R 6 T 3 Julio Luz
R 8 T 7 Julio Luz
R 8 T 8 Julio Luz
R 9 T 3 Julio Luz
R 9 T 8 Julio Luz
R14 T11 Julio Luz
R15 T 3 Julio Luz
R15 T 4 Julio Luz

GRAPH IV (*c*). Showing the flower behavior of avocado varieties under Group B.

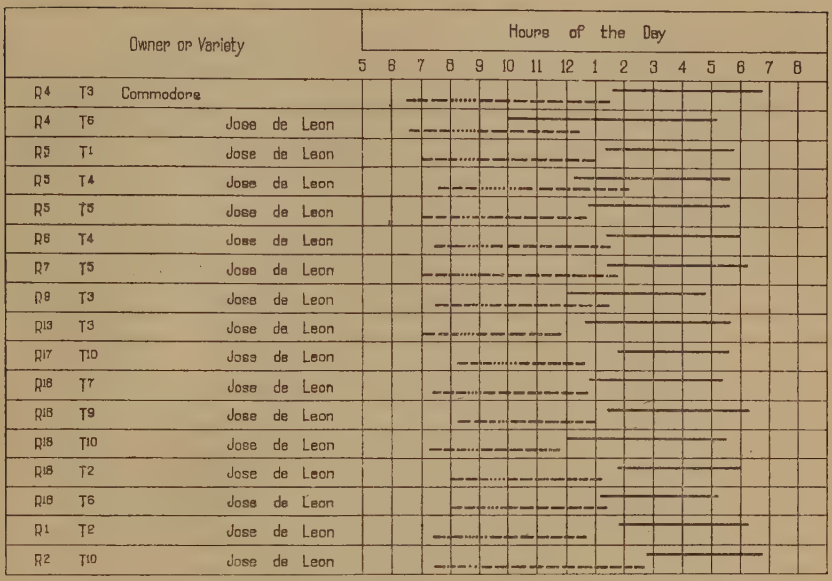
weather condition has retarded somewhat the opening and the closing of the flower of this variety. Furthermore, the rains started rather early in 1934.

In this study and as a guide for the avocado planters we have grouped the avocado varieties into two, as follows:

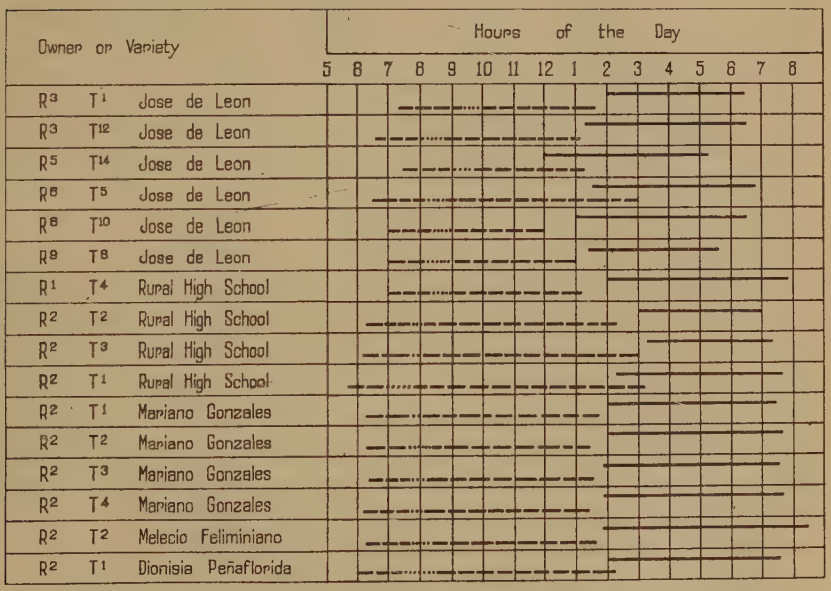
GROUP A.—Varieties whose first opening of flower is in the morning when the flowers function as females. This group has been subdivided further into three classes.

Class 1.—Varieties in which overlapping is occurring and the receptiveness of the stigma and the dehiscence of pollen coincide as for instance the Quality, Family, Dickinson, La Carlota No. 7, Commodore, and 51 trees of the unnamed varieties.

Class 2.—Varieties in which no overlapping of the two periods of opening occurs in the same tree. To this class belongs nine trees of the unnamed varieties.

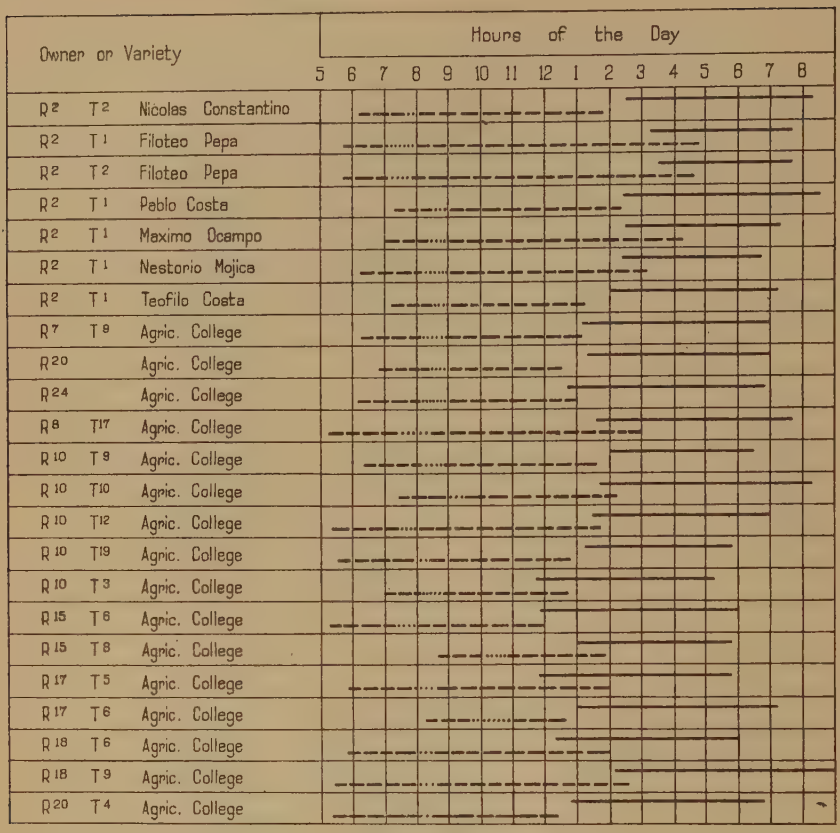

Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R4 T3 Commodore
R4 T6 Jose de Leon
R5 T1 Jose de Leon
R5 T4 Jose de Leon
R5 T5 Jose de Leon
R6 T4 Jose de Leon
R7 T5 Jose de Leon
R9 T3 Jose de Leon
R13 T3 Jose de Leon
R17 T10 Jose de Leon
R18 T7 Jose de Leon
R18 T9 Jose de Leon
R18 T10 Jose de Leon
R18 T2 Jose de Leon
R18 T6 Jose de Leon
R1 T2 Jose de Leon
R2 T10 Jose de Leon

GRAPH IV (*d*). Showing the flower behavior of avocado varieties under Group B.


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R3 T1 Jose de Leon
R3 T12 Jose de Leon
R5 T14 Jose de Leon
R6 T5 Jose de Leon
R8 T10 Jose de Leon
R9 T8 Jose de Leon
R1 T4 Rural High School
R2 T2 Rural High School
R2 T3 Rural High School
R2 T1 Rural High School
R2 T1 Mariano Gonzales
R2 T2 Mariano Gonzales
R2 T3 Mariano Gonzales
R2 T4 Mariano Gonzales
R2 T2 Melecio Feliminiano
R2 T1 Dionisia Peñaflorida

GRAPH IV (*e*). Showing the flower behavior of avocado varieties under Group B.

Class 3.—Varieties in which flower opening overlap but the receptiveness of the stigma and dehiscence of pollen do not coincide like the Avocado No. 1, Wester, Lyon, Cyrus (seedling), Lopena, and 64 unidentified trees.


Owner or Variety
Hours of the Day
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
R2 T2 Nicolas Constantino
R2 T1 Filoteo Pepa
R2 T2 Filoteo Pepa
R2 T1 Pablo Costa
R2 T1 Maximo Ocampo
R2 T1 Nestorio Mojica
R2 T1 Teofilo Costa
R7 T9 Agric. College
R20 Agric. College
R24 Agric. College
R8 T17 Agric. College
R10 T9 Agric. College
R10 T10 Agric. College
R10 T12 Agric. College
R10 T19 Agric. College
R10 T3 Agric. College
R15 T6 Agric. College
R15 T8 Agric. College
R17 T5 Agric. College
R17 T6 Agric. College
R18 T6 Agric. College
R18 T9 Agric. College
R20 T4 Agric. College

GRAPH IV (*f*). Showing the flower behavior of avocado varieties under Group B.

GROUP B.—Varieties whose first opening of flower is in the afternon when the flowers function as females and as males in the following morning. All varieties in this group fall under Class 2 and 3. Of Class 2 belong the Cardinal (budded and seedling), Cyrus (budded and seedling), Pollock (budded, grafted and seedling), Tumin, Wilson, Douglas, Avocado No. 5, Waldin, Vega, Cummins, Catalina, and 58 unidentified trees; and of Class 3 the Pollock (budded), Cardinal (seedling), and 57 unidentified trees.

SUMMARY

Fifty-nine trees consisting of 15 named and 29 unnamed varieties of avocado were observed during the 1933–34 flowering season in Lamao, Tanauan, Lipa and Mataas-na-kahoy. And during the 1934–35 flowering season 31 named and 217 unnamed trees were studied in Batangas, Bulacan, Cavite and Pampanga.

A study was made of the leaf buds and the flower buds. The flower buds are rounded and the scales and transition leaves developed more slowly than the leaf buds and are somewhat abnormal in size. The flower buds appeared early in August and were fully developed flowers from November up to May. In 1933–34 it took from 64 to 147 days for the flower buds to develop into panicles and 30 to 106 days for the panicles to the last appearance of the flowers, and in 1934–35 from 21 to 79 days and from 25 to 140 days, respectively. The majority of the flower buds originated from the terminal ends of the twigs; a few cases come from the axil of the leaves of the previous season growth and from large branches.

On heavy bearing trees practically all the twigs flowered. The flower panicles produced at the ends of the twigs were generally more vigorous than those produced elsewhere. The flower panicles borne at the tip of the terminal shoots contained an average of 162.9 florets and 203.8 for the panicles on the lateral twigs, but the peduncles of the former are longer and more stocky than the latter.

During the flowering season the trees were either heavily or slightly defoliated depending upon the number of flowers produced, and the formation of flowers was immediately followed by the development of new leaves with the exception of Family and a seedling of the Cyrus avocado where no leaf-fall occurred. Budded and seedling trees of the same variety may vary in the extent of their leaf-fall.

The avocado flowers are perfect and borne in clusters. They have two distinct periods of opening and closing, except those of one of the trees, owned by Mr. Whitaker, of Pampanga, which exhibited but one opening period. The stigma is receptive during the first opening and the pollen is shed during the second opening period. At the receptiveness of the stigma the corolla, nectaries and stamens lie in a flat plane or horizontal position. However, during the second stage or when the pollen was shed these flower parts were no longer in this position but rather slanting or hanging in outward direction.

The life cycle of an individual flower is longer in Group A than in Group B—34 against 24 hours in favor of the former.

The length of time for the opening of the flower, the dehiscence of pollen and the receptiveness of the stigma depends upon the variety and to the weather conditions, for climate influences the behaviors of the flowers. Budded and seedling trees sometimes behave differently too.

TABLE 5.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group A.*

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
R3T6	Unnamed	P. Whitaker	San Juan, San Fernando, Pampanga	S	372	25	347	6.72
R1T1	Lyon	Sotero Baluyot	San Fernando, Pampanga	S	474	31	443	6.54
R2T1	do	do	do	S	279	13	266	4.66
R1T2	Unnamed	Ramon Manio	San Marcos, Calumpit, Bulacan	S	240	13	227	5.42
R1T9	Lyon	do	do	B	115	0	115	0
R4T6	Unnamed	do	do	B	172	6	166	3.49
-T1	do	Isabel Aquino	Sambat, Taal, Batangas	S	352	0	352	0
-T1	do	Geronimo Rivera	do	S	295	20	275	6.78
-T1	do	Bibiano Kara	do	S	365	3	362	0.82
-T4	do	Cipriano Atienza	do	S	204	7	197	3.43
-T12	do	Evaristo Morada	Lipa, Batangas	S	226	12	214	5.31
-T3	do	Anacleto Makasaet	Pinagtungulan, Lipa, Batangas	S	162	4	158	2.47
-T4	do	do	do	S	250	3	247	1.20
-T1	do	Doroteo Makasaet	do	S	110	1	109	0.90
-T2	do	do	do	S	255	2	253	0.78
-T3	do	do	do	S	239	0	239	0
-T1	do	Cipriano Makasaet	do	S	186	4	182	0.78
-T2	do	do	do	S	210	3	207	1.43
R1T2	do	Vicente Malabanan	Balaknin, Lipa, Batangas	S	226	8	218	3.54
R1T3	do	do	do	S	157	2	155	1.27
R2T1	do	do	do	S	332	16	316	4.82
R3T2	do	do	do	S	378	0	378	0
-T1	do	do	do	S	125	9	116	7.20
-T3	do	do	do	S	276	5	271	1.81
R1T6	do	Arsenio Luz	Balete, Lipa, Batangas	S	119	9	110	7.56
R2T4	do	do	do	S	167	10	157	5.98

R2T7	do	do	do	S	219	5	214	2.27
R3T1	do	do	do	S	140	0	148	0
R3T2	do	do	do	S	174	0	174	0
R3T4	do	do	do	S	120	0	120	0
R1T3	do	Julio Luz	do	S	104	0	104	0
R2T4	do	do	do	S	189	13	176	6.88
R2T6	do	do	do	S	179	0	179	0
R4T1	do	do	do	S	137	11	126	8.03
R5T2	do	do	do	S	184	0	184	0
R6T5	do	do	do	S	186	9	177	4.84
R6T8	do	do	do	S	555	34	521	6.13
R13T2	do	do	do	S	147	8	139	5.44
R14T10	do	do	do	S	359	16	293	5.18
R15T9	do	do	do	S	205	6	199	2.93
R2T6	Family	Jose de Leon	Bañga, Talisay, Batangas	B	277	0	277	0
R3T8	Lyon	do	do	B	173	0	173	0
R6T3	Unnamed	do	do	S	174	0	174	0
R6T5	do	do	do	S	193	0	193	0
R9T2	do	do	do	S	150	0	150	0
R11T1	Lyon	do	do	B	196	0	196	0
R11T6	do	do	do	S	153	0	153	0
R11T9	Unnamed	do	do	B	229	0	229	0
R12T3	do	do	do	B	280	0	280	0
R12T4	do	do	do	B	165	16	149	9.70
R12T6	do	do	do	B	177	0	177	0
R12T9	do	do	do	B	208	0	208	0
R12T10	do	do	do	B	359	0	359	0
R14T9	do	do	do	B	288	0	288	0
R15T9	do	do	do	B	248	0	248	0
R16T5	do	do	do	B	234	0	234	0
R16T9	Commodore	do	do	B	322	0	322	0
R16T10	do	do	do	B	213	12	201	5.63
R17T8	Unnamed	do	do	B	243	0	243	0
-T1	do	do	do	S	94	0	94	0

NOTE.—B stands for budded plants, S for seedlings.

TABLE 5.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group A*—Ctd.

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
–T3	Unnamed	Jose de Leon	Bañga, Talisay, Batangas	S	173	0	173	0
–T4	do	do	do	S	165	0	165	0
–T7	do	do	do	S	159	0	159	0
R1T4	Lyon	do	do	B	210	0	210	0
R1T5	Unnamed	do	do	S	195	0	195	0
R1T11	do	do	do	S	288	2	286	0.69
R1T15	do	do	do	B	240	0	240	0
R2T14	do	do	do	B	290	0	290	0
R3T6	do	do	do	B	305	0	305	0
R3T9	do	do	do	B	244	0	244	0
R6T2	do	do	do	B	210	0	210	0
R6T3	do	do	do	B	148	0	148	0
R6T5	do	do	do	B	189	0	189	0
R6T8	do	do	do	G	166	0	166	0
R7T15	do	do	do	B	315	0	315	0
R8T10	do	do	do	Stock	276	0	276	0
R15T6	do	do	do	B	161	0	161	0
R15T9	do	do	do	B	169	0	169	0
R16T7	do	do	do	B	158	0	158	0
R1T1	do	Rural High School	Indang, Cavite	S	253	15	238	9.80
R1T5	do	do	do	S	279	74	205	26.52
–T1	do	Melecio Feliminiano	do	S	137	5	137	0
–T1	do	Francisco Creencia	do	S	111	13	98	11.71
–T1	do	Rosario Cruz	do	S	144	0	144	0
–T2	do	do	do	S	176	0	176	0

–T1	do	Nicolas Constantino	do	S	153	0	153	0
–T1	Family	Constancia Alano	do	S	268	31	237	11.57
–T1	Unnamed	Jose Zalazar	do	S	135	16	119	11.85
–T1	do	Simeon Madlansakay	do	S	271	23	248	8.49
–T2	do	Teofilo Casta	do	S	243	30	213	12.35
–T3	do	Agustin Creencia	do	S	114	9	105	7.89
–T5	do	do	do	S	126	14	112	11.11
R7T4	Lyon	Agricultural College	Los Baños, Laguna	B	119	12	107	10.08
R7T5	do	do	do	B	118	4	114	3.39
R8T20	Unnamed	do	do	S	93	0	93	0
R9T22	do	do	do	B	112	0	112	0
R10T3	do	do	do	S	236	0	236	0
R10T4	do	do	do	S	125	0	125	0
R10T5	do	do	do	S	126	0	126	0
R10T15	do	do	do	S	147	0	147	0
R10T18	do	do	do	B	126	0	126	0
R10T25	do	do	do	B	190	0	190	0
R11T13	do	do	do	B	147	0	147	0
R11T16	do	do	do	B	196	0	196	0
R11T20	do	do	do	B	97	0	97	0
R11T21	do	do	do	B	87	0	87	0
R11T24	do	do	do	B	129	0	129	0
R11T25	do	do	do	B	113	0	113	0
R12T12	do	do	do	B	223	0	223	0
R12T20	do	do	do	B	137	4	133	2.92
R13T5	do	do	do	B	79	0	79	0
R13T9	do	do	do	B	99	0	99	0
R13T17	do	do	do	B	86	0	86	0
R13T22	do	do	do	B	99	3	96	3.03
R13T24	do	do	do	B	38	3	35	5.36
R13T26	do	do	do	B	60	0	60	0
R14T12	do	do	do	S	206	0	206	0
R14T13	do	do	do	S	192	1	191	0.52
R15T2	do	do	do	S	153	8	145	5.23

NOTE.—B stands for budded plants, S for seedlings, and G for grafted plants.

TABLE 5.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group A*—Ctd.

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
R15T7	Unnamed	Agricultural College	Los Baños, Laguna	S	52	1	51	1.92
R16T4	do	do	do	S	331	0	331	0
R16T17	do	do	do	B	294	0	294	0
R16T20	do	do	do	B	43	0	43	0
R17T19	do	do	do	B	34	0	34	0

NOTE.—B stands for budded plants, S for seedlings, and G for grafted plants.

TABLE 6.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group B.*

R1T6	Unnamed	P. Whitaker	San Juan, San Fernando, Pampanga	S	498	15	483	3.01
R2T2	do	do	do	S	356	21	335	5.90
R2T3	do	do	do	S	238	16	222	6.72
R2T8	do	do	do	S	301	10	291	3.32
R1T2	do	Sotero Baluyot	San Fernando, Pampanga	S	520	35	485	6.73
–T2	do	Asuncion Lazatin	Mexico, Pampanga	S	232	17	215	7.33
–T4	do	do	do	S	213	11	202	5.16
–T1	do	Manuel Lazatin	Talabaskagan, S. Fernando, Pampanga	S	370	18	352	4.86
–T2	do	do	do	S	332	15	317	4.52
–T1	do	Eduardo Mendoza	Sambat, Taal, Batangas	S	328	9	319	2.74
–T2	do	do	do	S	280	26	254	9.29
–T3	do	do	do	S	367	9	358	2.45
–T1	do	Vicente Aquino	do	S	252	10	242	3.97
–T1	do	Policarpio Bendania	do	S	300	24	276	8.00
–T3	do	do	do	S	326	13	313	3.99

-T1	do	Cipriano Atienza	do	S	380	3	273	0.79
-T2	do	Glicerio Ramos	do	S	234	5	229	2.14
-T1	do	Ananias Atienza	do	S	341	20	321	5.87
-T3	Tertoh	Evaristo Morada	Lipa, Batangas	S	276	5	271	1.80
-T14	Unnamed	do	do	S	252	14	238	5.56
-T1	do	Anacleto Makasaet	Pinagtungulan, Lipa, Batangas	S	179	6	173	3.35
-T5	do	do	do	S	178	1	177	0.56
-T6	do	do	do	S	170	3	167	1.76
-T7	do	do	do	S	198	11	187	5.56
-T3	do	Cipriano Makasaet	do	S	190	8	182	4.21
-T5	do	do	do	S	264	27	237	10.23
-T6	do	do	do	S	207	11	196	5.31
-T7	do	do	do	S	232	10	222	4.31
R1T4	do	Vicente Malabanan	Bulaknin, Lipa, Batangas	S	220	3	217	1.36
R3T4	do	do	do	S	305	20	285	6.56
R3T5	do	do	do	S	229	20	209	8.73
R3T6	do	do	do	S	277	22	255	7.94
-T2	do	do	do	S	170	3	167	1.76
R2T5	do	Arsenio Luz	Balete, Lipa, Batangas	S	271	0	271	0
R2T8	do	do	do	S	381	24	357	6.30
R1T1	do	Julio Luz	do	S	296	7	289	2.40
R2T1	do	do	do	S	368	2	366	0.54
R4T3	do	do	do	S	312	0	312	0
R4T7	do	do	do	S	295	0	295	0
R5T1	do	do	do	S	256	0	256	0
R5T7	do	do	do	S	289	2	287	0.69
R6T3	do	do	do	S	200	13	187	6.50
R8T7	do	do	do	S	228	19	209	8.33
R8T8	do	do	do	S	165	0	165	0
R9T3	do	do	do	S	449	23	426	5.12
R9T8	do	do	do	S	101	0	101	0
R14T11	do	do	do	S	410	24	386	5.85
R15T3	do	do	do	S	173	0	173	0
R15T4	do	do	do	S	243	2	241	0.83

TABLE 6.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group B*—Ctd.

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
R3T1	Pollock	Jose de Leon	Bañga, Talisay, Batangas	S	173	0	173	0
R3T4	Cardinal	do	do	B	274	0	274	0
R3T5	do	do	do	B	215	8	207	3.73
R3T7	do	do	do	B	103	6	97	5.83
R4T3	Commodore	do	do	S	277	1	276	0.36
R4T5	Cardinal	do	do	B	145	1	144	0.69
R4T6	Unnamed	do	do	S	188	0	188	0
R5T1	do	do	do	S	216	0	216	0
R5T3	Cardinal	do	do	S	267	2	265	0.75
R5T4	Unnamed	do	do	S	207	0	207	0
R5T5	do	do	do	S	243	0	243	0
R6T4	do	do	do	S	287	5	282	1.74
R7T5	do	do	do	S	227	11	216	4.85
R9T3	do	do	do	S	216	0	216	0
R10T3	Cardinal	do	do	B	225	0	225	0
R10T5	do	do	do	B	182	0	182	0
R13T3	Unnamed	do	do	B	304	0	304	0
R17T10	do	do	do	B	234	0	234	0
R18T1	Cardinal	do	do	B	205	0	205	0
R18T7	Unnamed	do	do	S	261	0	261	0
R18T9	do	do	do	S	171	0	171	0
R18T10	do	do	do	B	239	0	239	0
–T2	do	do	do	S	237	0	237	0
–T6	do	do	do	S	144	0	144	0
R1T2	do	do	do	S	247	0	247	0

R2T10	do	do	do	B	180	0	180	0
R2T15	Cardinal	do	do	B	310	0	310	0
R3T1	Unnamed	do	do	B	207	0	207	0
R3T12	do	do	do	B	230	0	230	0
R3T14	Commodore	do	do	S	201	3	198	1.49
R3T15	Cardinal	do	do	B	209	0	209	0
R4T7	do	do	do	B	215	0	215	0
R4T11	do	do	do	B	148	0	148	0
R4T12	do	do	do	S	226	0	226	0
R5T13	do	do	do	B	337	0	337	0
R5T14	Unnamed	do	do	B	270	0	270	0
R6T5	do	do	do	Stock	223	0	223	0
R7T5	Cardinal	do	do	B	342	2	340	0.58
R8T10	Unnamed	do	do	B	168	0	168	0
R8T15	Cardinal	do	do	B	215	0	215	0
R9T8	Unnamed	do	do	S	201	0	201	0
R1T4	do	Rural High School	Indang, Cavite	S	148	13	135	8.18
R2T2	do	do	do	S	245	19	226	7.75
R2T3	do	do	do	S	219	15	204	6.85
-T1	do	do	do	S	358	94	264	20.80
-T1	do	Macario Gonzales	do	S	158	16	142	10.13
-T2	do	do	do	S	160	22	138	13.75
-T3	do	do	do	S	133	19	114	14.28
-T4	do	do	do	S	150	13	137	8.67
-T2	do	Melecio Feliminiano	do	S	265	40	225	15.09
-T1	do	Dionisia Peñaflorida	do	S	347	68	279	19.60
-T2	do	Nicolas Constantino	do	S	195	17	178	8.72
-T1	do	Filoteo Pepa	do	S	202	21	181	10.40
-T2	do	do	do	S	130	13	117	10.00
-T1	do	Pablo Casta	do	S	187	23	164	12.30
-T2	Cardinal	do	do	B	232	16	216	6.90
-T1	Unnamed	Maximo Ocampo	do	S	253	28	225	11.05
-T1	do	Nestorio Mojica	do	S	139	12	127	8.63
-T1	do	Teofilo Costa	do	S	155	15	140	9.68

NOTE.—B stands for budded plants, S for seedlings.

TABLE 6.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group B*—Ctd.

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
R7T9	Unnamed	Agricultural College	Los Baños, Laguna	B	148	13	135	8.78
R7T20	do	do	do	B	126	0	126	0
R7T24	do	do	do	B	140	4	136	2.86
R8T17	do	do	do	S	221	2	219	0.90
R10T9	do	do	do	B	179	0	179	0
R10T10	do	do	do	B	245	0	245	0
R10T12	do	do	do	B	60	0	60	0
R10T19	do	do	do	B	185	0	185	0
R14T3	do	do	do	B	58	0	58	0
R15T6	do	do	do	S	114	9	105	7.89
R15T8	do	do	do	S	71	0	71	0
R17T5	do	do	do	S	74	0	74	0
R17T6	do	do	do	S	92	14	78	15.22
R18T6	do	do	do	S	108	0	108	0
R18T9	do	do	do	S	211	0	211	0
R20T4	do	do	do	S	243	0	243	0
R17T2	Cardinal	Bureau of Plant Industry	Lamao Horticultural Station	B	207	11	196	5.31
R18T5	do	do	do	B	163	12	151	7.36
R19T4	Cyrus	do	do	B	150	3	147	2.00
R20T1	Cummins	do	do	S	126	9	117	7.14

NOTE.—B stands for budded plants, S for seedlings.

The fresh stigmas during the second opening period varied in the different varieties—from 0.52 to 26.52 per cent in Group A and from 0.36 to 20.80 per cent in Group B. The production of fruits of isolated trees which was due to the freshness of the stigmas during the second opening period of the flowers was less than the production of the trees where cross-pollination or overlapping of the opening periods occurred.

Fruit setting in avocado is properly accomplished by interplanting reciprocating varieties in the orchard provided pollinating agencies are present.

Avocado varieties were grouped into two; namely, A and B, according to the time of opening and closing of their flowers. The A's open their flowers first in the morning and the B's in the afternoon, both reopening in the afternoon and morning of the following day, respectively. The varieties under each group are given, together with their respective classes.

Varieties that can be interplanted as well as the self-compatible ones are given.

RECOMMENDATIONS

1. To produce a maximum yield in avocado, under normal weather conditions interplanting of reciprocating varieties should necessarily be done, and it may be accomplished as follows:

(*a*) By the hill or row alternate planting. The former is adapted for the yard planting and the latter for orchard planting.

(*b*) By partly topworking the old trees in the orchard comprising but one variety with reciprocating varieties.

(*c*) By planting seeds. This is not recommended since sexually grown plants do not usually come true to type.

2. The varieties to be interplanted should have approximately the same flowering time—early varieties should not be interplanted with late varieties and vice-versa. The midseason varieties can be interplanted with either the early or late varieties.

3. Of the best locally grown avocados the Family, Lyon and Wester in Group A can be interplanted with the Cardinal and Pollock in Group B.

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ILLUSTRATIONS

FIG. 1. Buds of Wester avocado. (*a*) Flower bud. (*b*) Leaf bud.
2. Flower clusters produced from the trunk of La Carlota No. 2 avocado, topworked on Dickinson variety.
3. Various stages of flowers of Cyrus avocado. (*a*) Top view of a flower open for the first time. (*b*) Side view of the same flower. (*c*) Top view of a flower open for the second time. (*d*) Side view of the same flower.

SIX YEARS OF TOBACCO BREEDING

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TEN PLATES

An earlier paper(1) prepared by the writer presented the reasons and the need of developing distinctly Philippine wrapper types, suited to our conditions, of medium-sized leaf and dual purpose breeds by hybridization. Of the native varieties, the Vizcaya, which approaches a wrapper type except for certain objectionable coarse characters and qualities, was chosen as female parent crossing it with Sumatra strain and constant hybrids thereof. The theme of that article served as the *raison d'etre* of the breeding work reported in the following pages.

Time and place.—This work was started and carried on for two seasons, 1928–29 and 1929–30, at Hacienda San Antonio of the Tabacalera, Ilagan, where the writer was employed for three years, and was continued for four seasons, 1930–31, 1931–32, 1932–33, and 1933–34, at the Ilagan Tobacco Station, Isabela.

THE CROSSING WORK: 1928–29 SEASON

The different parents used and hybrids made.—During this season, the work was crossing. In this large wrapper plantation with half a million Sumatra plants of six strains and a quarter of a million Vizcaya plants grown during the season, the work could be carried out with greater material and with more choice of parent plants than in a small plantation. The writer was given complete charge of seed selection and hybridization work, and had the whole plantation at his disposal to work on. The great number of Vizcaya plants was especially favorable for the choice of desirable plants for crossing. Since the five hybrids made had the object of improving the Vizcaya in the direction of wrapper production, the writer was guided

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by the description of Priego(2) in the selection of the pure Vizcaya type, which says:

> Tabaco Vizcaya (*Nicotiana tabacum habanensis*).—Tallos herbáceous de 2 m. a 2.8 m. de altura, de hojas sentadas, auriculadas y abrazando el tallo en toda su circumferencia, las superiores enderezadas y lanceoladas, las inferiores horizontales y vales, acuminadas, lustrosas, verde claras y de gran desarrollo. Flores paniculadas, cáliz oblongo, con divisiones desiguales, corola tres veces más larga que el cáliz, embudada y de color purpureo.
>
> Procede de Cuba y su introducción data del primer término del siglo (XIX). Se cultiva como una de las más preferidas por los cosecheros de la provincia (Isabela) y su nombre se refiere al antiguo de la misma.

It may be of interest to mention some facts regarding the varieties and constant hybrids used in this hybridization work.

Vizcaya.—Originally the seed of this variety came from the Valley of Magat, Isabela, and was in culture in the plantation for several seasons, and during this season, in the intensive Sumatra culture for wrapper production. Except when shaded with standard cheesecloth, it did not produce as great a percentage of wrappers as the Sumatra nor had the same desirable qualities. The type described by Priego could be easily distinguished in this large plantation. Owing to the elaborate wrapper culture, the plants grew superbly. This type served as the female parent of four of the crosses made. Some mosaic, of which this variety is very susceptible, appeared in some parts of the plantation. (Plate 1.)

Baker Sumatra.—This is the best Sumatra wrapper strain, the result of intensive selection in the defunct Pikit and Sarunayan Tobacco Stations, Cotabato, Mindanao, since its introduction in 1921. It produces the greatest percentage of fine wrappers with desirable colors and with the finest veins of all Philippine Sumatra strains. Under Cagayan Valley conditions, however, it produces mostly second length wrapper (30–38 cm.). The seed in pure condition was brought by the writer to the plantation. (Plate 1.)

Sumatra American-grown.—This was imported privately by the Tabacalera in 1928 from the United States. It looks much like an ordinary Sumatra and produces more fallow colored leaves. Conditions being equal, the leaves are smaller than those of the Baker Sumatra and are not so smooth or clean looking. The leaves cure with slightly more of the greenish cast than desired.

Philippine Sumatra.—This is Sumatra which was perhaps a mixture of the three Sumatra strains previously introduced into

the country from Sumatra; namely, Baker Sumatra, S. P. No. 1, and S. P. No. 2. It produces slightly coarser leaves than either the Baker Sumatra or the Sumatra American-grown. The present plantation was the result of mass selection in the preceding season.

Ax–11.—This is a constant strain of a cross made in Pikit, Cotabato, in 1922, with Baker Sumatra as the female parent and Florida Sumatra as the male parent(3). It has a vigorous rapid growth with somewhat narrow leaves but longer than the leaves of the Sumatras. It surpasses others in uniformity of color in the cured leaf. It produces the most fallow-colored leaves that are mostly first length. Its defects are its narrow breadth, index, 52 per cent, and slightly coarse veins. The leaves are carried to an acute angle. It has pinkish white flowers. (Plate 2.)

Bx–27.—It is a pure line and constant strain of the reciprocal cross of Ax–11 with Florida Sumatra as the female parent and Baker Sumatra as the male parent. It looks more like the Baker Sumatra, but with larger leaves and greater height. The marked distinguishing characteristic is the beautifully well diffused pink color of its large flat corolla. The leaves generally cure light brown and have an excellent flavor. Like the female parent, it is susceptible to mild mosaic infection, especially during the last stages of growth. Because of inherent good elasticity after proper fermentation, the mosaic leaves are not weak or badly blemished. (Plate 2.)

Both the Ax–11 and Bx–27 were also brought to the plantation by the writer.

The following hybrids were made during the 1926–29 tobacco season:

Symbol	Cross	Object
Fx	Vizcaya X Ax-11	To obtain light colors and greater elasticity.
Gx	Vizcaya X Bx–27	For greater breadth index, more rapid growth, and fine leaves.
Hx	Vizcaya X Baker Sumatra	For mosaic resistance and fine leaves.
Ix	Vizcaya X Sumatra American-grown	Fine veins and more fallow colors.
Kx	Philippine Sumatra X Vizcaya	For dual purpose.
Jx	Ax–11 X Sumatra American-grown	Fine veins and greater breadth index.

With the exception of the Jx-hybrid, all the other crosses have the Vizcaya with the object to improve it in the direction of wrapper leaf production for medium-sized wrapper leaf(1).

During the season of crossing, the Vizcaya plantation was infested with serious mosaic disease. The Baker Sumatra growing side by side with the Vizcaya was also infested with the disease, but not in so serious proportions. Therefore, in making the Vizcaya and Baker Sumatra cross with the object of mosaic resistance, the most resistant plants of both varieties in the worst infested lots were chosen for the crossing.

The technique of tobacco hybridization.—As many sets of from 10 to 20 plants were selected as there were number of crosses to be made, which were six. Every plant was labelled with a piece of *coco* cloth bearing in Chinese ink the plant number and the specific cross, as "25 Vizcaya × Baker Sumatra," meaning the figure for the number of the plant, the first name the female parent and the second, the male. In order that the numerous plants to be crossed could be properly attended, the writer trained a few very careful laborers to help him in this work. To avoid mistakes, the laborers were divided into groups, each group working on a specific cross day by day with the help and supervision of the writer. The groups carried lists of the number of female plants and when crossing and emasculation were finished on a particular plant, the number of the plant was checked for that date. In this way, all the plants of each cross could be pollinated and their new flowers emasculated. There were in all 124 female parents. The hybridization was made in the months of January and February, 1929.

The flower heads of the female and male parents were each enclosed with cheesecloth bag, 70 cm. long, made cylindrical with the aid of two wire No. 16 rings, 30 cm. in diameter. The bags were supported by small bamboo poles firmly thrust into the ground close to the plant with the cross pieces to suspend the bag. The bag was suspended at the upper end by means of a jute string; the bag could be raised as the plant grew higher. Some of the plants were very tall, necessitating the use of three-legged bamboo ladder in order to do the work well. (Text fig. 1.)

The flowers of the female parents were emasculated by simply splitting the corolla and removing all the stamens a day or two previous to the time when the stigma is in a receptive condition. During the emasculation, any flower that had any of its five stamens already burst or have burst during the operation was removed. Generally, emasculation was made when the tip of the closed corolla began to show slight signs of pinkish colo-

ration, or when the flowers have sufficiently developed but not yet open. Dehiscence generally begins at 5 to 8 a. m., depending upon whether the pollen sacks have sufficiently opened. On clear days, the pollen is dry and is in good condition for this work. The receptive condition of the stigma can be easily known by a change of color from green to dirty white, by its swollen appearance and moist condition. The pollen of the flowers from the male parents were simply touched to the stigma of the emasculated flowers of the female parents without the use of the fingers or any instrument. The work was mostly done between 5:30 to 11 a. m. The hybridization work on one plant required from 2 to 4 weeks. When sufficient pods have set, all the new flowers and flower buds were removed, the number of pods counted, and when matured were primed as in harvesting the leaves.

The pods were thoroughly dried separately for each cross in seed drying tables or in shallow boxes in the shade. After thorough drying, the pods were threshed, cleaned, and placed in bottles. Powdered napthalene were placed on top of the seeds, the bottles were corked, sealed with ordinary sealing wax, and stored for the next season.

THE F_1 GENERATION: 1929–30 SEASON

The seeds of the six different hybrids were sown separately in October, 1929. For the comparison, the different hybrids were planted side by side in a field of one wrapper grower.

During the F_1 generation, the plants of each hybrid were uniform and showed intermediate characters of the parents used.

During this season, the commercial wrapper plantation of three hectares, planted to other tobacco was attacked by mosaic disease, starting from the field of a careless grower and spreading all over the plantation. Since some of the hybrids were planted in the middle of the plantation, they naturally were infested also with the disease. Observations showed that among the hybrids, the Hx F_1 (Vizcaya $\times$ Baker Sumatra) was the least attacked.

Some notes were taken of the behavior of the hybrids in the field and the qualities of the finished leaves.

Fx F_1 (*Vizcaya* $\times$ *Ax–11*).—This hybrid appeared more like native tobacco. The plants showed intermediate characters of both parents. It produced the tallest plants among the hybrids and produced an average of 30.9 leaves per plant. It had a longer period of growth than Ax–11, almost behaving like the

Vizcaya. In general the cured and fermented leaves were of light brown color, lighter in color than the ordinary Vizcaya leaf, and had better elasticity.

Gx F_1 (Vizcaya × Bx–27).—The plants manifested rapid growth and great vigor with very broad and large leaves. It was the most striking of all the hybrids. At a glance the F_1 plantation was similar to Pampano, but different in having the smooth leaves, broad and erect when young, turning horizontal at maturity—a Vizcaya characteristic. Some of the plants after the flush of vigorous growth developed a mild infection of mosaic disease on the upper standard and top leaves. This mild mosaic disease may be due to poor nutrition during the last stages of growth, although it may also be due to some infection to which the plantation is exposed or to some disease inherent in the plant. This mild infection did not arrest the development of the plants as in a serious mosaic disease. It produced an average of 27.5 leaves per plant. The fermented leaves were fine with light color.

Hx F_1 (Vizcaya × Baker Sumatra).—This cross showed intermediate characters of both parents. The plants were of green color and the characteristic light color of the Vizcaya was not evident. The plants produced an average of 27.1 leaves per plant. The leaves cured well and produced a good proportion of fine and light colored leaves. As stated above, it was the least attacked by the serious mosaic infection that affected the plantation.

Ix F_1 (Vizcaya × Sumatra American-grown).—The plants showed intermediate characters of both parents. The green leaves were smooth with clean appearance. It produced an average of 27.5 leaves per plant. The fermented leaves showed more of the fallow color than any of the hybrids.

Jx F_1 (Ax–11 × Sumatra American-grown).—This cross differed from the others in not having any native "blood." It was of the small wrapper leaf type, for improving the Ax–11 in some of its defects such as narrow leaves and coarse veins. It has very whitish pink flowers—an Ax–11 characteristic. A few plants had their flowers entirely white. The average number of leaves per plant was 23.1. Like the Ax–11 and the American Sumatra, it produced light fallow colored leaves after fermentation. It was the earliest maturing of the hybrids.

Kx F_1 (Philippine Sumatra × Vizcaya).—This cross showed about the same characters as the Hx F_1, being practically the reciprocal cross, except that the Sumatra female parent was not

the Baker Sumatra. The plants did not show as vigorous growth as the Hx F_1. It produced an average of 23.6 leaves per plant. The leaves cured fairly well with same light colored fine leaves.

The best plants of these hybrids were bagged for breeding. The number of plants selected from each cross were as follows: Fx F_1—20 plants; Gx F_1—36 plants; Hx F_1—64 plants; Ix F_1—40 plants; Jx F_1—36 plants; and Kx F_1—50 plants.

THE F_2 GENERATION: 1930–31 SEASON

Since the plantation was dedicated more to the commercial production of wrapper leaves, only two, the Gx and Jx hybrids, were chosen to be planted on a large scale. The two growers who planted the Gx F_2 had 27,595 plants and the other grower who planted the Jx F_2 had 8,845 plants. Some of the mass selected seeds and extra seedlings of these two hybrids and the others were given to some Hacienda tenants, the idea being to have them grow the hybrids and later to inspect their tobacco fields in order to make some initial selections. The rest of the selected seeds were kept.

Seed sowing in beds began on September 8 and was continued weekly for 5 weeks. On October 23, transplanting was started in the intensive Sumatra method of culture.

The Gx F_2 showed very great variability. The grand parental types of the male parent Bx–27, namely Florida Sumatra and Baker Sumatra, showed some representatives, although rare(4). Six good types were easily distinguished.

Type A.—Plants vigorous, Florida Sumatra-like, color dark green, with smooth, fairly elliptical leaves with obtuse tips, erect with acute angles of insertion. Good wrapper type. Somewhat early. Plants very rare. (Plate 4.)

Type B.—Similar to type A, except that the leaves at maturity are carried horizontally on the stem, with narrower leaves. There were more representatives than in type A. Fairly good wrapper type.

Type C.—Plants vigorous, Baker Sumatra-like, but morphologic characters in greater proportions; color, dark green. Young leaves with swollen appearance. Plants very rare. Good wrapper type.

Type D.—Plants very vigorous with rapid development; easily strikes the attention for having large broad leaves, like the native Pampano. This was the heterozygous type of the Gx in the F_1 generation. Good as a dual purpose type. (Plate 4.)

Type E.—Plants vigorous with light green color; leaves not as large as those of type D with somewhat yellow specks, a Bx–27 characteristic. Leaves somewhat swollen and wavy when young, turning smooth when mature.

Type F.—Plants Vizcaya-like with somewhat narrow pointed broadly-winged leaves with light to dark colors.

There were also other not well-defined types, which were discarded. Some of these were of doubtful value. One rare type that called forcibly one's attention is a plant with a rosette but with the leaf margin very wavy or surly, showing decorative effect.

Likewise, the Jx F_2 was segregated into Sumatra, intermediate, and Ax–11 types. The intermediate type was good for wrapper work.

In December, 1930, when this culture was pending, the writer left the employ of the company. As there was no disposition to continue the selection and purification work necessary in hybrids for the lack of a technically trained man at the plantation he made the suggestion that the two types A and B should be selected for wrapper work and type D for dual purpose of Gx hybrid, and the intermediate type of the Jx hybrid.

Late station culture of the F_2 generation.—As the F_2 culture at the plantation did not yet produce seeds at the time of his departure, he was given the F_1 seeds of the hybrids. Seed beds were made in January and the hybrids were planted in plots of 500 square meters each at the Ilagan Tobacco Station. Owing to the lateness of the season and consequent stunted development precluding the possibility of isolating the desirable mother plants from each cross and the limited plant population, no selection was made, reserving this work in the F_3 generation. Better selection could be made in the next generation with more plants grown in the right season to select from. Moreover, with an extra generation the promising hybrids could be known and the selection from these could be accordingly stressed. The best plants from each cross had their flower heads bagged and the seeds were stored for the next season.

THE F_3 GENERATION: 1931–32 SEASON

As above stated, no strain selections during the F_2 generation was made. For lack of sufficient seed, the Fx F_3 was cultured in a breeding plot consisting of the set of station and other hybrids. The Jx F_3 was cultured with the small-leafed Sumatra hybrids.

The Gx, F_3, Hx F_3 and Kx F_3 for medium-sized leaf wrapper, were cultured in duplicate plots of $\frac{1}{8}$ of a hectare each. Five standard seed beds for each cross were sown on October 12, 1931, and after 50 days, the seedlings were transplanted in the duplicate plots. The purpose of this test was to compare the behavior of these hybrids in the F_3 generation and to make the initial individual plant selections for certain desirable characters or quality, stressing the selections on the most promising among them. (Plate 5.)

The calculated yield per hectare and the percentage of marketable wrapper leaves for each cross were as follows: Gx F_3, 1,864 kilos with 24.7 per cent; Hx F_3, 1,140.8 kilos with 27.9 per cent; Ix F_3, 949.6 with 32.5 per cent; and Kx F_3, 692.8 with 13 per cent. In an earlier planting of Ix F_3 in our San Vicente Hill lot we obtained a yield of 1,063 kilos per hectare with 33.2 per cent wrapper. In this plot test, the following facts were observed: The best yielder with the largest leaves was the Gx F_3. The hybrid that gave the most percentage of marketable wrapper leaf was the Ix F_3, although the yield was not high, followed by Hx F_3. The poorest result as to yield and percentage of wrapper was obtained from Kx F_3 hybrid. The Hx F_3 was the least susceptible to mosaic infection, being only 0.8 per cent from a population of 3,744 plants. This being less than 1 per cent, was of no consequence even in a wrapper field.

Those fairly large duplicate plots of $\frac{1}{8}$ of a hectare each, or $\frac{1}{4}$ of a hectare devoted to each hybrid in this test and the other lot of Ix F_3 consisting of 2,770 square meters in the early hill planting afforded us with sufficient material to make our initial selection for line work.

In this generation the same types in the Gx F_3 as enumerated in the F_2 were found. (Figs. 5 and 6.) The Ix F_3 showed also considerable variability and a few specific types may be described as follows:

Type A.—Good wrapper strains with large and broad leaves, but rather rare.

Type B.—Strains with leaves not as broad as the first type carried at an acute angle. Also rare.

Type C.—Sumatra-like early strains with small leaves.

Type D.—Late flowering strains with many close-set leaves, carried horizontally at maturity with more Vizcaya characters.

Type E.—Intermediate type partaking characteristics of both parents, leaves fairly long and borne far apart.

There were also poor and worthless types which were discarded.

In the Hx F_3 and Kx F_3 there were not so much variability as shown by Gx F_3 and IX F_3. However, in the Hx F_3, besides the intermediate and a few other types, there were found very late strains with numerous close-set small leaves, but larger than Sumatra leaves.

The lower and middle standard leaves of the selected plants were harvested and labelled separately, cured, and fermented. While the living plant may appear perfect, its fermented leaves may be defective in any of the important particulars, such as, texture, venation, color, elasticity, and other desirable features in the finished leaf. This is carrying the selection of desirable plants one step farther, and is carried less erringly, because the final decision of the value of selected tobacco strain lies in the industrial value of the leaf. This close scrutiny is the more necessary in a hybrid strain than in a strain selected from a standard variety—especially on the product of the progeny of selected mother plants—as the varying character or quality may be due to heterozygosity. The homozygous lines for certain characters or quality can be better isolated, besides the uniformity shown in the best rows, by the uniformity of the fermented leaf, because the characters or qualities seen in the finished product are hidden from the eye in the green leaves however perfect they may look. A pertinent illustration of this method of rigid selection will be given in the discussion of test row results. It is for the reasons above mentioned that many of our initial selections were at once discarded without the necessity of culturing them, because of serious defects in their fermented leaves.

THE F_4 GENERATION: 1932–33 SEASON

A number of selections were sown in beds on October 11, 1932, allowing one strain for every 5-square-meter bed. This separate sowing precluded seed mixing. The seeds of the following selections were sown separately:

Cx F_4—32 selections, Ix F_4—32 selections, Hx F_4—18 selections, and Kx F_4—6 selections.

There were therefore originally sown in seed beds 88 selections of four hybrids.

During the seed-bed period, the weather was so abnormal because of the continuous and excessive rainfall and the three successive storms of October 24, November 11, and December 6, 1932. Consequently, our seed beds suffered severe losses in seedlings. After the first storm, the selections that had remnant seeds were replanted; in other cases there were no more seeds to replant. There were also some numbers where only a few seedlings survived after the bad weather. In view of these losses we could not carry out our original plan of running sufficiently replicated test rows of all the 88 selections.

Plant-to-the-row tests—Duplicated.—The next best thing to do was to select the numbers with more than 200 seedlings surviving for each selection, and then to run duplicate rows of 100 plants each in Plots A and B. One row of each strain appeared in the same order in both dots. The following were the selections cultured in these duplicated plant-to-the-row tests:

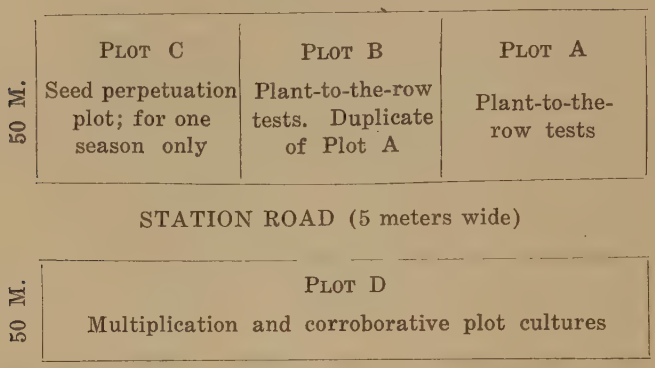
Gx F_4–14, –16, –19, –30, –34, –43, –48, –51, –56, or 10 strains.
Hx F_4–1, –3, –9, –16, –17, or 5 strains.
Ix F_4–1, –2, –3, –4, –5, –12, –14, –16, –17, –20, –21, or 11 strains.

There were 26 selections tested of three hybrids only.

The extra seedlings from the above mentioned plant-to-the-row tests and others of the replanted seed beds were planted in Plot D in rows or in plots as the number of seedlings warranted. There were two reasons for doing this. If some of the test rows should eventually be selected, we would have an extra plot to get more seed from. In this way, we would be doing for the valuable strains during this season the work of two seasons, to retrieve our lost work in the F_2 generation. These plots of extra seedlings should give corroborative or other data for our duplicate test rows. The numbers appearing in varying number of rows in Plot D were the same as those in Plots A and B.

All the other numbers that could not give sufficient seedlings for duplicate rows were planted in Plot C. The object was to perpetuate for another season the seeds of these for another trial, should the test rows in Plots A and B fail to give us some results.

The outlay of our breeding plots may be seen in the following diagram:



Transplanting in these plots began on December 10, 1932, and was continued until finished. Plots A and B were planted on the same day. Plants were uniformly spaced 90 cm. between rows and 50 cm. between plants for all plots. When the plants were about 30 cm. high, they were alternately cultivated with the small 5-tooth Calamba cultivator and the large Batangueño cultivator, in order to ridge the rows. After a series of two cultivations with these implements, the loose earth left between the rows were brought to the ridges by the tjankol (large Malayan hoe), thus rounding the ridges and making them better.

In this report of the F_4 generation we are mostly concerned with the results of our duplicate test rows in Plots A and B and the data presented refer to the strains cultured in them. Unfavorable conditions have narrowed our work to three, out of four, hybrids, which fortunately were good material to work on, as found out in our plot tests in the previous season. For corroboration of certain specific characters found in the test rows, we resorted to our Plot D. In this way, what we lacked in more replications was partly supplied by our multiplication and corroborative plot cultures and the reported results were of more value.

Data secured from each test row.—From each test row, data were obtained which may be grouped as follows:

Stalk character;
Green leaf characters, quantitative and botanical;
Plant characters;
Diseases and pest data;

General test row data, including market distinguishing characteristic, if any;
Fermented leaf characters; and
Yield and percentage of wrapper leaves.

The above data were grouped in Tables 1 and 2. These data with some exceptions are generally obtained in the ordinary study of quantitative and qualitative characters in selections. Twenty plants picked at random from each test row were measured and studied and the average results with the errors of the mean are presented in Table 1.

"Wrapper production index."—Attention is invited to the recording of the number of leaves one meter from the ground. The principal reason for getting this is that this work is for wrapper production, and under normal conditions, the performance of the plant one meter from the ground is a good index of its capacity for wrapper production. In any wrapper variety or strain, the fine wrapper leaves are found in this region, where the sand, lower, and middle standard leaves are located; above this region the upper standard and top leaves are generally found, and these are to be considered as wrapper leaves. If the circumference of the stem, the length of internode, and more especially the *number of leaves* are known 1 meter from the ground, the wrapper leaf production can be roughly gauged. In order to see this clearly for the number of leaves only, the writer advances a way of expressing it in terms of percentage, and for want of a better term, may be called "wrapper production index." This is obtained by dividing.

$$\frac{L}{1} \text{ by } \frac{TL}{H} \text{ multiplied by } 100$$

in which L represents the number of leaves 1 meter from the ground, 1 is the unchanging number for 1 meter, TL, total number of leaves of the plant and H, the whole height of the plant. For example, a plant has 20 leaves 1 meter above the ground, the total number of leaves is 40 and the plant has a height of 2 meters, then we have

$$\frac{20}{1} + \frac{40}{2} \times 100, \text{ or } \frac{20}{1} \times \frac{2}{40} \times 100 \text{ or } 100\%$$

When the wrapper production index is 100 per cent, there are as many leaves in the 1 meter region as above it and the plant may be considered a good wrapper leaf producer; when it is above 100 per cent the plant is an excellent wrapper leaf producer; and when it is less than 100 per cent the plant may be a poor producer of wrapper leaves.

TABLE 1.—*Showing stalk characters, green leaf characters, including botanical description, plant characters, and percentage attacked by mosaic and suspected mosaic.*

Hybrid name	Line number	Stalks characters					
		Average mean height	One meter from ground			Wrapper production index. Average	Average mean length internode
			Average mean circumference	Average mean length internode	Average mean number of leaves		
		cm.	*cm.*	*cm.*		*Per cent*	*cm.*
G×F4	14	242.4+1.809	8.4+0.097	6.75+0.127	14.95+0.194	122.8	8.3+0.201
G×F4	16	237.2+2.016	8.12+0.066	7.7+1.390	13.4+0.191	108.5	8.1+0.125
G×F4	19	219.5+3.286	7.7+0.075	7.2+0.119	13.8+0.121	110.1	7.8+0.094
G×F4	30	192.0+2.328	6.6+0.097	6.3+0.217	16.2+0.451	110.4	6.9+0.098
G×F4	34	183.3+1.972	7.6+0.085	4.2+0.061	24.8+0.155	132.5	5.3+0.718
G×F4	43	199.5+4.645	7.9+0.106	5.7+0.129	19.9+0.308	113.8	5.6+0.129
G×F4	48	198.0×1.775	7.4+0.808	6.6+0.118	15.9+0.231	110.0	7.2+0.115
G×F4	51	197.9+1.758	8.0+0.146	5.3+0.045	17.8+0.298	127.6	7.1+0.075
G×F4	55	215.6+4.192	7.7+0.097	6.2+0.264	17.4+0.501	135.0	7.9+0.144
G×F4	56	222.0+1.683	7.6+0.068	6.7+0.135	15.5+0.201	118.0	7.3+0.159
H×F4	1	198.0+2.187	8.2+0.086	3.9+0.083	28.6+0.221	132.0	4.8+0.075
H×F4	3	199.4+3.119	7.2+0.099	4.9+0.136	21.0+0.462	140.0	7.2+0.166
H×F4	9	184.8+1.994	7.8+0.056	4.3+0.075	25.0+0.357	135.0	5.4+0.071
H×F4	16	186.8+3.273	7.4+0.067	4.2+0.080	24.0+0.369	137.0	5.9+0.111
H×F4	17	200.3+0.189	6.9+0.091	5.4+0.097	21.4+0.278	126.0	5.9+0.111
I×F4	1	211.6+2.036	8.9+0.110	6.9+0.062	16.4+0.151	111.9	6.7+0.108
I×F4	2	206.7+1.453	7.1+0.065	8.1+0.106	14.0+0.144	115.7	8.6+0.087
I×F4	3	222.5+1.433	7.6+0.068	8.2+0.136	14.8+0.175	124.0	8.3+0.070
I×F4	4	220.3+1.900	7.6+0.088	7.5+0.133	16.5+0.392	135.1	7.8+0.120
I×F4	5	205.7+2.845	8.7+0.088	6.8+0.097	16.4+0.221	115.9	6.9+0.129
I×F4	12	194.3+1.871	7.5+0.069	5.0+0.157	23.6+0.403	136.6	5.8+0.090
I×F4	14	200.9+3.799	7.2+0.069	6.9+0.094	15.0+0.242	125.5	8.2+0.119
I×F4	16	202.8+2.623	7.7+0.187	6.5+0.083	17.5+0.228	111.6	6.4+0.960
I×F4	17	179.2+1.599	7.2+0.089	5.1+0.125	21.8+0.272	128.5	6.2+0.079
I×F4	20	201.9+2.413	7.1+0.106	7.2+0.099	14.9+0.097	113.9	7.6+0.087
I×F4	21	228.9+1.885	8.3+0.091	7.0+0.123	15.1+0.181	118.3	7.1+0.085

Hybrid name	Line number	Green leaf characters				
		Average mean total leaves	Average mean angle of insertion	Middle standards		
				Average mean length of leaves	Average mean breadth	Average mean breadth index
			Degrees	*cm.*	*cm.*	*Per cent*
G×F4	14	29.4+0.437	43.0+0.905	59.8+0.799	34.4+0.439	57.6+0.711
G×F4	16	29.3+0.551	45.8+1.116	56.9+0.613	33.9+0.652	58.6+0.875
G×F4	19	27.7+0.274	47.3+0.694	61.4+0.568	32.6+0.432	53.6+0.504
G×F4	30	26.9+0.369	46.7+1.158	54.2+0.965	31.3+0.718	57.9+0.652
G×F4	34	34.3+0.507	41.7+0.685	56.0+0.784	28.0+0.579	50.9+0.558
G×F4	43	34.0+0.785	59.0+0.685	57.0+0.677	32.5+0.479	57.2+0.678
G×F4	48	27.0+0.289	48.7+1.207	56.0+0.635	30.8+0.505	54.6+0.613
G×F4	51	27.6+0.337	49.2+1.222	62.1+0.471	35.3+0.606	56.7+0.606
G×F4	55	27.0+0.436	55.0+1.357	57.0+0.492	31.7+0.406	55.4+0.709
G×F4	56	29.0+0.722	49.0+1.014	60.6+0.548	32.8+0.406	53.9+0.533
H×F4	1	42.9+0.669	52.3+0.919	50.8+0.362	24.9+0.359	48.9+0.444
H×F4	8	29.9+0.845	51.8+0.691	48.1+0.121	27.6+0.443	57.5+0.626
H×F4	9	34.0+0.449	49.0+0.528	46.8+1.274	23.9+0.247	50.9+0.504
H×F4	16	32.7+0.546	53.5+0.679	50.8+0.096	26.6+0.346	52.2+0.634
H×F4	17	34.2+0.676	50.7+0.685	45.9+0.684	27.0+0.453	58.7+0.652
I×F4	1	31.0+0.181	48.8+0.709	56.7+0.483	35.3+0.377	62.2+0.577
I×F4	2	25.0+0.305	49.7+0.733	51.0+0.377	30.7+0.504	60.3+0.578
I×F4	3	26.5+0.259	54.5+0.711	56.9+0.754	28.3+0.471	48.5+0.606
I×F4	4	26.9+0.478	51.0+0.679	51.0+0.603	26.7+0.527	53.2+0.749
I×F4	5	29.1+0.231	46.0+0.685	55.3+0.445	32.4+0.444	58.5+0.503
I×F4	12	33.7+0.428	43.7+0.748	49.2+0.812	26.7+0.469	54.4+0.635
I×F4	14	24.0+0.196	44.5+0.108	48.7+0.626	25.7+0.377	52.7+0.406
I×F4	16	31.8+0.323	48.3+0.799	49.6+0.918	29.0+0.588	57.1+0.579
I×F4	17	30.4+0.397	49.3+0.961	49.3+0.649	26.8+0.483	51.6+0.799
I×F4	20	26.4+0.347	45.3+0.842	52.0+0.558	29.4+0.539	56.3+0.558
I×F4	21	29.2+0.343	54.8+0.879	58.3+0.579	32.3+0.444	55.4+0.539

TABLE 1.—*Showing stalk characters, green leaf characters, including botanical description, plant characters, and percentage attacked by mosaic and suspected mosaic*—Continued

Hybrid name	Line number	Green leaf characters								Plant characters				Disease
		Position of leaves (1)	Shape (2)	Surface (3)	Color (4)	Margin (5)	Base (6)	Petiole (7)	Apex (8)	Uniformity (9)	Form of plant (10)	Form of head (11)	Color of flowers (12)	Mosaic
														Per cent
G×F4	14	FE	Ov	FSm	LG	SU	AC	BW	A	U	Lan	Op	VLP, D	16.9
G×F4	16	FE	Ov	SW	G	SU	AC	BW	Obt	U	Lan	Cp	LP, D	15.5
G×F4	19	FE	Ov	SW	LG	SU	AC	BW	A	U	Lan	FCP	LP	18.4
G×F4	30	FE	Ov	W	G	SU	AC	BW	Obt	FU	Lan	FCp	LP, FD	19.9
G×F4	34	E	Ov	Sm	G	En	AC	BW	A	U	Con	Cp	WP	9.8
G×F4	43	H	Ov	VW	G	SU	AC	BW	A	U	Lan	Cp	LP	11.0
G×F4	48	FE	Ov	VW	LG	SU	AC	BW	A	U	Lan	CP	P	14.3
G×F4	51	H	Ov	Sm	G	SU	AC	BW	Obt	U	Lan	FCp	WpP	17.6
G×F4	55	FE	Ov	Sm	G	SU	AC	BW	A	NU	Lan	CP	P, D	21.4
G×F4	56	FE	Ov	Sw	LG	SU	AC	BW	A	U	Lan	Cp	P, FD	24.5
H×F4	1	E	Ov	Sm	G	SEn	AC	BW	A	U	Lan	Op	P	15.0
H×F4	3	E	Ov	Sm	G	En	AC	BW	A	U	Lan	Op	P	8.5
H×F4	9	E	Ov	Sm	G	SU	AC	BW	A	U	Lan	Op	P	24.2
H×F4	16	FE	Ov	Sm	DG	SU	AC	BW	A	U	Lan	Op	P	11.5
H×F4	17	E	Ov	SW	G	SU	AC	BW	A	U	NP	Op	P	29.9
I×F4	1	FE	Ov	SW	LG	SU	AC	BW	A	U	Cyl	Cp	WP, D	30.5
I×F4	2	FE	Ov	W	LG	SU	AC	BW	A	U	Lan	Cp	P	19.9
I×F4	3	H	Ov	W	G	SU	AC	BW	A	U	Lan	SOp	LP, D	12.4
I×F4	4	H	El	W	G	SU	AC	BW	Obt	NU	Lan	FOp	P, D	22.4
I×F4	5	FE	Ov	W	DG	En	AC	BW	Obt	U	Con	Cl	LP	14.9
I×F4	12	E	El	W	LU	SU	AC	BW	A	U	Lan	FCP	LP	39.4
I×F4	14	FE	Ob	Sm	G	SU	AC	BW	Obt	U	Lan	FCP	L, PD	42.5

I×F4	16	H	O	Sw	G	En	AC	BW	Obt	U	Lan	Cl	W, nD	52.6
I×F4	17	FE	Ov	W	G	En	AC	BW	Obt	U	Lan	Op	PW, nD	32.0
I×F4	20	FE	Ov	Sm	G	En	AC	BW	Obt	U	Lan	Cp	LP	47.8
I×F4	21	H	Ov	W	G	SU	AC	BW	Obt	U	Lan	Op	LP	31.4

(1) E=erect, EE=fairly erect, H=horizontal.
(2) Ov=ovate, ob=oblong, El=elliptic.
(3) Sm=Smooth, W=wavy, SW=slightly wavy, VW=very wavy, Swo=swollen.
(4) G=green, LG=light green, DG=dark green.
(5) En=entire, U=undulate, SU=slightly undulate.
(6) AC=auriculate clasping.
(7) BW=broadly winged.
(8) A=acute, Obt=obtuse.
(9) U=uniform, FU=fairly uniform, NU=non-uniform.
(10) Lan=lanceolate, Con=conincal, cyl=cylindrical, NP=nearly pyramidal.
(11) Op=open, Cp=compact, FCp=Fairly compact, SOp=slightly open Cl=closed.
(12) P=pink, LP=light pink, VLP=very light pink, D=diffused, FD=fairly duffused, WP=whitish pink, WpP=white patched with pink.

Importance of marked botanical characters.—There were also recorded some botanical characters common to the plants of each test row. This recording is the more necessary in hybrid strains than in line selections from standard varieties, because of the wider variation manifested in hybrid strains and because each homozygous strain or line may give rise to a new race(5). Moreover, in our tobacco work for many years, we were able to identify certain varieties and very often one or two distinguishing characters like plant form, color of flowers, the way the leaves are attached to the stem, etc., guided us in the practical separation or identification of standard varieties in mixed plantings without resorting to the infinite details of botanical descriptions, keys, or measurements.

Enumeration of objects of line selection.—Since our line of work in the F_4 generation narrowed down to three hybrids only, it may not be amiss to repeat here by enumerating the specific characters and qualities we were selecting and others that were noted in the results as of value, and in our discussion of results to mention the specific lines or strains isolated for a definite purpose. However, it should be mentioned in passing that a certain selected line may have one or more of these characters and qualities, as for example, a line with a high breadth index may coincidentally have fallow color in greater proportion than others, or a medium early strain may have leaves with very fine veins and also a high wrapper production index, etc. In other words, a selected line may show more than one of the definite objects in breeding and the more the strain has them, the nearer it approaches the *ideal* wrapper tobacco plant, provided that these characters are not diametrically opposed, as medium early and late characters. Our selection were for the following:

A. Wrapper yield
B. Mosaic resistance
C. Uniformity of color
D. High breadth index
E. High leaf number
F. High wrapper production index
G. Fineness of veins
H. Fallow (aceitunado) color
I. Elasticity and suppleness
J. Medium early wrapper strains
K. Late wrapper strains
L. Dual-purpose strains
M. Trueness to type

Besides these definite objects, the breeder is always on the lookout for novelties or chance mutants, the sudden appearance of which will give him great surprise and add zest to his labors. And he has a great chance of obtaining mutant in hybrids (8, 6). Such a giant mutant with very high leaf number suddenly arose at Hacienda San Antonio, Ilagan, Isabela, in the F_8 generation of the pure hybrid line Bx–27 in the season of 1928–29 (1).

Applied plant breeding.—In this work of hybridization followed by line selection and strain tests under review, it will be noted that the writer was more concerned in breeding as an art to produce wrapper and dual-purpose types for the tobacco growers by the isolation of pure and constant strains than in studying laws or corroborating them and other phenomena connected with hybridization. The principles of genetic science and the laws discovered by tobacco breeders of other more advanced tobacco countries served as groundwork and guided us in this task.

Discussion of test row results.—From the data presented in Table 1, the following were found:

In stalk characters there was a considerable variability shown by the different progenies in the test rows. Of importance in wrapper work, the number of leaves one meter from the ground varied for Gx hybrid from 13.4 + 0.191 for Gx F_4–16 to 24.8 + 0.155 for Gx F_4–34; for Hx hybrid from 21.4 + 0.462 for Hx F_4–3 to 28.6 + 0.221 for Hx F_4–1; and for Ix hybrid from 14 + 0.144 for Ix F_4–2 to 23.6 + 0.403 for Ix F_4–12. The wrapper production index ranged in Gx hybrid from 110.4 per cent for Gx F_4–30 to 135 per cent for Gx F_4–55; in Hx hybrid from 126 per cent for Hx F_4–17 to 140 per cent for H_4–3; and in Ix hybrid from 111.6 per cent for Ix F_4–6 to 136.6 per cent for Ix F_4–12.

Likewise, the quantitative characters of the green leaves showed a very marked variation among the test rows. The average number of leaves is of great importance. In this character the variation was 26.9 + 0.389 for GxF_4–30 to 34.3 + 0.507 for GxF_4–34; 29.9 + 0.845 for HxF_4–3 to 42.9 + 0.669 for HxF_4–1; and 24 + 0.196 for HxF_4–14 to 33.7 + 0.428 for IxF_4–12.

The way the leaves are carried on the stem, which can be measured approximately as the angle of insertion of the leaves is a character that has a marked influence on the quality of the wrapper leaves produced. Generally, the smaller the angle of

insertation, the more erect are the leaves, the variation in the angle of insertion were from 41.7 + 0.685 degrees for GxF_4–34 to 59 + 10.685 degrees for GxF_4–43; from 49 + 0.628 degrees for HxF_4–9 to 53.5 + 0.679 degrees for HxF_4–16; and 43.7 + 0.748 degrees for IxF_4–12 to 58.3 + 0.579 for IxF_4–12.

The average mean length and breadth of the middle standard leaves showed great variation among the different strains of the three hybrids.

In leaf breadth index, the variation ranged from 50.9 + 0.558 per cent for GxF_4–34 to 58.6 + 0.875 for GxF_4–16; from 48.9 + 0.444 per cent for HxF_4–1 to 58.7 + 0.652 per cent for HxF_4–17; and from 51.6 + 0.799 per cent for IxF_4–17 to 62.2 + 0.577 per cent for IxF_4–1.

In the botanical characters of the plant and the leaves, while within each hybrid, there were several of these that were the same, yet in some lines or strain there were noticed a few marked differences. These few differing botanical marks, such as position of leaves, shape, surface, color, margin, apex, plant form, form of head, and color of flowers will serve to distinguish one from another as new races. Owing to the close scrutiny for conformity in these respects of the plants within every line studied, it is expected that these different characters will breed true in the purified and constant strains.

In order to get the actual percentage of the plants attacked by the mosaic disease, the whole number of plants in each test row and in the multiplication plot belonging to that row were counted as were also those with mosaic or with suspected mosaic disease. The close proximity of the test rows with one another, allowing vicinity infection, the care of including all the plants with suspected mosaic disease, the abnormally bad weather during their culture and the station land being infested with the disease made the percentage of attacked plants somewhat high in some of the lines. The different test rows showed considerable variation in mosaic susceptibility. The susceptibility and near resistance to this disease of the selected lines could be more accurately taken from larger cultures.

In Table 2 the general test row data, including marked distinguishing characters noticeable at a glance, yield and percentage of wrapper leaves, and fermented leaf characters were combined. In these respects the comparison of the test rows should be made within each of the three hybrids studied. Uniformity of the plants in each of the test was of the first consideration, any row lacking uniformity was considered as still

segregating and was not selected. As to the description of types, reference should be made to the F_2 and F_3 cultures of Gx hybrid and Ix hybrid, respectively. In the selection of the best test rows, adherence to one type only was not thought advisable, because each of the types mentioned had some qualities that recommended themselves. In the development and precocity of the plants, there were variations. There are mentioned for each test row such marked distinguishing characters noticeable at a cursory glance of the plants in the row.

In the yield data, the results of two test rows for each strain were combined and the total number of the plants in the duplicate rows were taken. Because of the only two replications, the number of plants involved was so small to go into separate data for each replication. For the lack of more replications, prevented by the loss of seedlings owing to bad weather, the accuracy of the yield of each strain may suffer, but not the different desirable characters and qualities studied in the strains, a combination of which decided the value of the lines selected for further work. The total average yield per plant in grams and the percentage of wrapper leaves are the limits in this study. In some cases the percentage of wrapper leaves apparently appear high. This is because our classification took into account all the fine and medium fine leaves as wrappers; or all the leaves that fell into the different superior and inferior classes of wrappers in strictly commercial classification. In no case, however, did any strain exceed 69 per cent, the amount generally obtained in pure Sumatra culture in the Cagayan Valley. The range of these percentages lies within the limits between a pure Vizcaya and pure Sumatra large commercial wrapper culture results.(1)

On account of the small quantity of leaves from not more than 200 plants for each strain, the wrapper leaves could not be separated into the many commercial wrapper classes. The results merely serve to compare the lines of each hybrid among themselves. The average yield per plant in grams is given, consisting of both wrapper and filler leaves. In this study, taking the plant as a basis, the result should not be taken as final. The production per hectare basis and the amount of each class of wrappers of the selected lines should be more accurately and reliably taken from larger cultures for several seasons.

As stated elsewhere in this study, the selection of the strains should be carried also in the fermented leaves, which will give

TABLE 2.—*Showing general test row results, including marked distinguishing characteristics of each, yield performance per plant in grams, percentage of wrapper leaves, and principal fermented leaf characters.*

Hybrid name	Line number	Uniformity of plants in the row	Type	Maturity	Development	Precocity	Marked distinguished characteristics
G×F⁴	14	Uniform	B	Medium early	Uneven	Partly precocious	Leaves medium broad; erect when young horizontal when mature.
G×F⁴	16	do	B	Early	Fair	Precocious	Leaves erect when young, turning horizontal at maturity.
G×F⁴	19	do	E	do	do	Partly precocious	Leaves erect, somewhat narrow, light brown.
G×F⁴	30	Nonuniform	E	do	Poor	Nonprecocious	Bx-27-like, leaves medium sized.
G×F⁴	34	Uniform	A	Medium early	Good	do	Leaves carried at an acute angle, cabbage-like.
G×F⁴	43	do	B	Late	Fair	do	Close-set leaves; very wavy. Top leaves with decorative effect.
G×F⁴	48	do	E	Medium early	Good	Precocious	Bx-27-like; leaves have swollen appearance, flowers diffused pink.
G×F⁴	51	do	D	do	do	do	Leaves erect when young; broad and horizontal at maturity; flowers very light pink.
G×F⁴	55	Nonuniform	No special type	Medium early	Fair	Partly precocious	Non-uniformity.
G×F⁴	56	Uniform	F	Late	Good	Nonprecocious	Vizcaya-like, leaves horizontal, leaves light green.
H×F⁴	1	do	Sumatra type	do	Fair	do	Leaves small, many, close-set like cabbage; erect. Mutant for high leaf number.
H×F⁴	3	Nonuniform	do	Medium early	Fair	Partly precocious	Nonuniformity.
H×F⁴	9	Uniform	do	do	do	Nonprecocious	Leaves erect and narrow.
H×F⁴	16	do	do	Early	do	Fairly precocious	Leaves somewhat narrow; erect.
H×F⁴	17	do	do	Medium early	Good	Precocious	Broad leaves.
I×F⁴	1	do	A	Late	Excellent	Nonprecocious	Large and broad erect leaves.
I×F⁴	2	do	C	Medium early	Good	Precocious	Sumatra-like, tall with small stems.
I×F⁴	3	do	D	do	Excellent	do	Vizcaya-like, long narrow leaves.
I×F⁴	4	Nonuniform	C	do	Fair	Nonprecocious	Sumatra-like, leaves erect with coarse veins.
I×F⁴	5	Uniform	A	Late	Good	Precocious	Broad, fairly erect leaves, dark green.
I×F⁴	12	do	C	Early	Fair	do	Young leaves erect, convex. Spoon-like; light pink flowers.

I×F⁴	11	do	C	do	do	Precocious	Small leaves; small stem.
I×F⁴	16	do	A	Medium early	do	Nonprecocious	Small, erect, broad leaves.
I×F⁴	17	do	C	Early	do	Precocious	Small close-set leaves; clean looking and smooth.
I×F⁴	20	do	C	Medium early	Poor	Partly precocious	Small broad leaves; compact flower head.
I×F⁴	21	do	D	Late	Fair	Nonprecocious	Vizcaya-like, erect leaves when young, turning horizontal at maturity.

TABLE 2.—*Showing general test row results, including marked distinguishing characteristics of each, yield performance per plant in grams, percentage of wrapper leaves, and principal fermented leaf characters*—Continued.

Hybrid name	Line number	Yield of test rows				Total number of plants	Average yield per plant in grams	Fermented leaf characters			Remarks
		Weight in kilos			Per cent wrappers			General color of wrappers	Characters of veins	General textures and suppleness	
		Wrappers	Fillers	Total							
G×F⁴	14	7.8	11.8	19.6	39.8	200	98	Light brown	Fairly fine, somewhat irregular.	Fine; elastic glossy, smooth leaves.	Selected for further strain test.
G×F⁴	16	7.2	7.8	15.0	48.0	197	76	Fallow to light brown.	Fine, regular	Fine; fairly elastic and glossy.	
G×F⁴	19	7.0	4.8	11.8	59.3	198	59.6	Light brown	Coarse	do	
G×F⁴	30	5.8	6.2	12.0	48.3	198	60.6	do	Fairly fine; irregular	Fairly elastic somewhat glossy.	
G×F⁴	34	7.6	6.6	14.2	54.6	192	74.0	Homozygous for light brown color.	Fairly fine; regular	Very elastic and glossy.	Do.
G×F⁴	43	6.4	6.6	13.0	49.2	178	70.0	Light brown	Fine; numerous and irregular.	Elastic	
G×F⁴	48	4.2	5.2	9.4	4.7	188	50.0	do	Fairly fine; regular	Fine; elastic and glossy	Do.
G×F⁴	51	6.8	7.0	13.8	49.3	195	70.8	Light brown to fallow.	do	Fine and smooth elastic and glossy.	Do.
G×F⁴	55	4.8	4.2	9.0	53.3	170	53.0	Light brown to multicolored.	Fairly fine; irregular	Fairly elastic; somewhat glossy.	Do.
G×F⁴	56	5.2	6.2	11.4	45.6	193	59.0	Brown to fallow	Fairly fine; regular	Fine; elastic somewhat glossy.	Do.
Y×F⁴	1	7.2	7.4	14.6	49.3	186	78.0	Light brown	Fine; regular	Elastic, glossy	Do.
Y×F⁴	3	4.6	7.5	12.1	38.0	190	63.7	do	Fairly fine; regular	Fairly elastic	
Y×F⁴	9	4.4	5.4	9.8	44.9	196	49.0	do	Fairly fine; irregular	do	
Y×F⁴	16	6.4	5.8	12.2	52.5	198	62.0	Light brown to fallow.	Fine; regular	Elastic and glossy	Do.

Y×F⁴	17	3.0	7.6	10.6	28.3	194	54.0	Light brown	do	Fairly elastic	Do.
I×F⁴	1	14.2	12.2	26.4	53.8	198	133.0	do	Fine; regular, placed well apart.	Elastic and glossy	Do.
I×F⁴	2	8.2	6.0	14.2	57.7	194	73.0	Brown to light brown.	Fairly fine; irregular	Not very elastic	Do.
I×F⁴	3	10.4	6.8	17.2	60.5	196	88.0	Fallow.	Fine; regular	Fine; elastic, very glossy.	Do.
I×F⁴	4	6.0	7.4	13.4	44.8	195	69.0	Light brown	Prominent veins, regular.	Fairly fine; fairly elastic and glossy.	
I×F⁴	5	6.0	8.8	16.8	47.7	197	85.0	Light brown to multicolored.	Coarse	Fairly-fine; fairly elastic.	Do.
I×F⁴	12	7.4	6.9	14.3	51.0	198	72.0	Light brown to fallow.	Fine; very regular	Fine; elastic and glossy	Do.
I×F⁴	14	3.3	3.5	6.8	48.2	185	37.0	do	Fine	do	
I×F⁴	16	5.4	8.4	13.8	39.1	199	69.0	Light brown	Fairly fine; regular	do	
I×F⁴	17	4.6	4.4	9.0	51.1	182	49.0	do	Prominent veins, irregular.	Fairly fine; not elastic nor glossy.	
I×F⁴	20	2.8	3.8	6.6	42.4	161	41.0	Light brown to multicolored.	Somewhat coarse regular.	Fairly fine; fairly elastic, not glossy.	
I×F⁴	21	4.2	4.8	9.0	46.6	155	58.0	do	Fairly fine; regular	Fine; elastic and glossy	Do.

TABLE 3.—*Showing the especially pronounced and other less marked characters and qualities of the hybrid lines selected for further strain tests.*

Hybrid and line number	A. Wrapper yield	B. Near mosaic resistance	C. Uniformity of color in the leaf	D. High breadth index	E. High leaf number	F. High wrapper production index	G. Fineness of veins	H. Fallow color	I. Elasticity and suppleness	J. Medium early wrapper strain	K. Late wrapper strain	L. Dual purpose strain	M. Trueness to type
G×F4–14	SP		SP	S		S	S		S	S		S	SP
G×F4–34	SP	SP	SP		SP	SP	S		SP	S			SP
G×F4–48		S				S	S		SP	S			SP
G×F4 51	S			S		SP	S	S	S	S			SP
G×F4–56					S	S	S	S	S		S	SP	SP
H×F4–1	SP	S			SP	SP	S		SP		S		SP
H×F4–16		SP	S		SP	SP	S	S	SP				SP
H×F4–17				SP	SP	S	SP			S			SP
I×F4–1	SP			SP	SP	S	SP		SP		SP	SP	SP
I×F4–2	SP			SP		S	S			S			SP
I×F4–3	SP	SP	SP			SP	SP	SP	SP	S		SP	SP
I×F4 5	SP	S		SP	S	S					SP	SP	SP
I×F4–12	SP			S	SP	SP	SP	S	SP				SP
I×F4–21	S		SP		S	S			SP		SP	SP	SP

NOTE.—The abbreviation SP means selected for pronounced or marked character or quality; S, for character or quality not well marked.

While there are 13 objects of selection enumerated in this table, under J and K, a strain can be either medium or late maturing and under L, a strain may or may not be a dual-purpose strain, so that in the discussion only 11 objects are mentioned that a strain or line may have out of the thirteen.

an industrial value to the selection. This rigid scrutiny of the finished product started with leaves of the initial selections and was continued in the produce of the test rows. A beautiful field appearing test row may disclose some few serious defects in the finished leaves. A patent example of this is the IxF_4–5. This row showed great uniformity, good development, high breadth index, dark green color, and other visible desirable field characters, altogether appearing very promising in the field. The fermented leaves, however, showed prominent veins, and a tendency for multicolored leaves, which are serious wrapper defects. It was, however, retained for further strain test. But with a large quantity of produce in a more propitious season, if it should continue to manifest these objectionable features, it may eventually be eliminated as a wrapper strain.

The selected lines.—Based upon the 11 objects of our selection, the characters, qualities, and adaptation of each strain or line selected appear in Table 3. These are sets of characters and qualities mentioned for each strain. Of the eleven objects, when the test row showed some pronounced character or quality, that particular character or quality was marked as SP in the table. When the character or quality was not especially marked, but present in most of the plants or the leaves it was marked S. In other words, this difference is one of degree with the small number of plants studied. It will be seen in this table that there are lines that have several pronounced characters, and there are also some lines with less of these. Likewise, there are also some lines that had several characters that were not marked, and also other lines with less. To illustrate our meaning: Line GxF_4–34 was especially good in wrapper yield, near mosaic resistance, uniformity of color in the leaf, high leaf number, high wrapper production index, elasticity and suppleness, and came true to type. It had fairly fine veins and was of medium adaptability, but these were not so pronounced as the others. It lacked high breadth index, a defect in a wrapper strain. It could not be considered a dual-purpose strain. The point to be stressed in presenting this table is to show graphically and quickly the number of these two sets of characters and qualities and those also that are absent (marked with a dash) in each of the lines selected. Discounting a few opposing characters, in no case is there a line that has all these qualities. None of our selections, therefore, can be considered the ideal wrapper tobacco strain, but a few are approaching this desideratum. Attention is invited to the following lines in the order named

for each hybrid that have the most desirable qualities: GxF_4–34, GxF_4–14, GxF_4–56; HxF_4–1, HxF_4–16; IxF_4–3, IxF_4–1.

COMPARATIVE STRAIN TESTS OF THE SELECTED F_5 LINES OF THREE HYBRIDS: 1933–34 SEASON

In order to compare the selected strains of each hybrid among themselves, especially as to uniformity, constancy and wrapper yielding ability, to select the lines approaching the ideal wrapper tobacco plant, and to study their adaptability to local conditions and methods of culture and comparative near resistance to disease and pests, tests of 5 selected lines of GxF_5 hybrid, 5 of IxF_5 hybrid, and 3 of HxF_5 hybrid were carried out at the Ilagan Tobacco Station, Isabela, during the 1933–34 season.

Method of procedure.—There were three sets of tests as follows:

I. 5 lines of GxF_5 hybrid; namely, GxF_5–14, –34, –48, –51, and –56.
II. 5 lines of IxF_5 hybrid; namely, IxF_5–11, –2, –3, –5, and –21.
III. 3 lines of HxF_5 hybrid; namely, HxF_5–1, –16, and –17.

The first two series were planted at the same time and in identical manner while the third series consisting of the HxF_5 strains were planted three weeks later.

Seeds (6 grams per bed) of each strain of the first two groups were sown on October 16, 1933, in three standard beds of 12 square meters each. As a precaution against untoward conditions, a bed of each strain was simultaneously sown in the hill lot in order to produce reserve seedlings.

Two seed beds for each strain of the HxF_5 hybrid were sown on November 8, 1933.

Seeds germinated from 6 to 8 days. The parts of the beds with thick growth of seedlings were thinned to about 5 centimeters each way.

Seedlings were transplated 45 days after sowing in a previously well prepared ground. A dose of 10 grams of 14N–16P–12K complete fertilizer was placed in each hole, mixed with fine earth before the seedling was set. The rate of application was 220 kilograms per hectare. The rows were spaced uniformly at 90 centimeter and the plants at 50 centimeters between them. The five strains were planted in succession, allowing one row of 95 meters long each and were replicated 10 times. One-Half of the hectare block was occupied by the GxF_5 hybrid and the other half, by the IxF_5 hybrid. Plantings of these two hybrids were carried out at the same time.

The HxF_5 hybrid strains were planted in small plots, but also replicated 10 times.

All the seed bed and field operations were uniform for all the strains.

Before harvest 10 plants from each row or 100 plants for each strain of the GxF_5 and IxF_5 hybrids and 25 plants each of the HxF_5 hybrid were labelled for measurements or for obtaining other data. All these data are arithmetically averaged, as shown in Table 4. Only a small number were used of each strain of the HxF_5 hybrid, because plants that sustained aphid infestation were not thought advisable to be included as normal plants.

In harvesting the leaves, the 5 regional classes were separately picked.

Two methods of curing the leaves were used.

1. *Wrapper cure.*—All fine and sound leaves from sand, lower and middle standards were cured as wrapper tobacco and totally in the shade.

2. *Filler cure.*—All badly broken, blemished or coarse leaves of the above three regional classes and the upper standards and top leaves were cured in the ordinary manner as filler tobacco. These were sticked and partially wilted and dried in the sun, completing the curing in a standard shed.

These two types of leaves were fermented separately. The wrapper mandala after four turnings reached 54° C. and the filler after several turnings, 50° C.

Both products from each row of 10 replications were separately weighed after fermentation. The product of each row was roughly classified by bundles into fine, medium fine, and thick leaves, as shown in Table 5. After obtaining the weights each of the three classes was combined separately for the commercial classification of the leaves. These data are shown in Table 6.

Interpretation of results.—For obvious reasons the average of the test row results contained in Tables 1 and 2 should not be compared in exact and complete detail with the average results of the strain tests as contained in Tables 4, 5, and 6, except in a relative way. Rather, the strain tests results should serve to compare the strains of each hybrid among themselves and to verify or corroborate every object, as shown graphically in Table 3, which determined their selection. Obviously, strains were selected which satisfied the greater number these objects

TABLE 4.—*Showing the average stalk, green leaf, and plant, characters; and other data of the strain tests.*

Name and strain number	Stalk characters					Green leaf characters									
	Average height	One meter from ground			Average length of internode	Average total leaves	Average angle of insertion	Average length of leaves	Average breadth of leaves	Average breadth index	Position of leaves (1)	Shape (2)	Surface (3)	Color (4)	Margin (5)
		Average circumference	Average length of internode	Average number of standard leaves											
	cm.	*cm.*	*cm.*		*cm.*		*Degrees*	*cm.*	*cm.*	*Per cent*					
G×F5–14	230.9	8.0	6.6	10.8	36.8	30.5	48.2	56.9	32.1	56.4	FE	Ob	Fm	LG	SU
G×F5–34	184.7	8.0	3.4	16.3	3.5	37.1	45.4	59.6	30.4	50.8	E	Ov	SM	LG	U
G×F5–48	225.8	7.7	7.1	11.2	7.2	26.2	48.6	57.1	33.6	58.8	E	Ov	VW	LG	U
G×F5–57	223.0	7.6	5.6	12.0	5.7	27.8	48.7	61.1	34.8	56.9	FE	Ov	Sm	G	U
G×F5–56	213.2	7.8	7.6	10.1	7.6	29.8	50.0	59.7	33.6	56.3	E	Ov	VW	G	U
I ×F5–1	214.4	8.6	7.5	10.5	17.5	30.6	48.0	60.8	38.1	62.6	FE	Ov	SW	G	U
I ×F5–2	251.3	6.7	8.9	9.2	9.0	25.9	44.0	53.6	33.3	62.1	FE–E	Ov	FW	LG	U
I ×F5–3	241.9	7.2	8.2	10.2	8.2	27.9	46.9	62.4	32.0	51.3	H	Ob	SW	LG	U
I ×F5–5	218.2	8.4	7.5	11.1	7.2	28.6	43.0	60.6	36.7	60.5	FE	Ov	W	DG	SU
I ×F5–21	250.5	8.2	8.0	10.0	8.2	27.9	45.8	61.9	34.8	56.4	E–H	Ov	W	G	SU
H×F5–1	202.8	7.6	5.6	--------	--------	33.3	--------	56.6	28.3	50.0	E	Ov	Sm	G	En
H×F5–16	227.7	7.8	6.6	--------	--------	28.0	--------	54.3	27.5	50.6	FE	Ov	Sm	G	SU
H×F5–17	228.5	7.0	7.4	--------	--------	30.0	--------	52.5	29.2	35.8	E	Ov	Sm	G	SU

(1) E = erect, FE = fairly erect, H = horizontal.
(2) Ov = ovate, Ob = oblong, El = elliptic.
(3) Sm = Smooth, W = wavy, SW = slightly wavy, VW = very wavy, Swo = swollen.
(4) G = green, LG = light green, DG = dark green.
(5) En = entire, U = undulate, SU = slightly undulate.

TABLE 4.—*Showing the average stalk, green leaf, and plant, characters; and other data of the strain tests*—Continued.

Name and strain number	Green leaf characters			Plant characters						
	Base (6)	Petiole (7)	Apex (8)	Uniformity (9)	Form of plant (10)	Form of head (11)	Color of flowers (12)	Per cent mosaic	Attack of other diseases	Marked distinguishing characters
G×F5–14	AC	BW	A	U	Lan	Cp	VLP, D	35.7	Not serious	Leaves medium broad, erect when young, horizontal at maturity.
G×F5–34	AC	BW	A	U	Con	Cp	WP	33.8	do	Numerous leaves carried at acute galen, cabbage-like.
G×F5–48	AC	BW	A	U	Lan	Cp	P, D	34.6	do	Bx-27-like, leaves with swollen appearance, flowers diffused pink.
G×F5–57	AC	BW	obt	U	Lan	FCp	WpP	49.8	do	Flowers very high pink. Young leaves erect, broad and horizontal at maturity.
G×F5–56	AC	BW	A	U	Lan	Cp	P, FD	47.8	do	Vizcaya-like, leaves horizontal and light green.
I ×F5–1	AC	BW	A	U	cyl	Cp	P	19.6	do	Large and broad exact leaves.
I ×F5–2	AC	BW	A	U	Lan	Cp	P	13.4	do	Sumatra-like, tall with slender stems.
I ×F5–3	AC	BW	A	U	Lan	SOp	P	13.5	do	Vizcaya-like, long, narrow leaves.
I ×F5–5	AC	BW	obt	U	Con	FOp	P	12.3	do	Broad dark green leaves.
I ×F5–21	AC	BW	obt	U	Lan	Op	LP	13.7	do	Vizcaya-like erect young leaves horizontal at maturity.
H×F5–1	AC	BW	A	U	Lan	Op	P	5.0	do	Sumatra-like resistant to mosaic.
H×F5–16	AC	BW	A	U	Lan	Op	P	7.0	do	Sumatra-like resistant to mosaic.
H×F5–17	AC	BW	A	U	NP	Op	P	7.0	do	Sumatra-like resistant to mosaic.

(6) AC = auriculate clasping.
(7) BW = broadly winged.
(8) A = acute, obt = obtuse.
(9) U = uniform, FU = fairly uniform, NU = non-uniform.
(10) Lan = lanceolate, Con = conical, cyl = cylindrical, NP = nearly pyramidal.
(11) Op = open, Cp = compact, FCp = Fairly compact, SOp = slightly open, Cl = closed.
(12) P = pink, LP = light pink, VLP = very light pink, D = diffused, FD = fairly diffued, WP = whitish pink, WpP = white patched with pink.

TABLE 5.—*Showing the average production per plot, computed yield per hectare, and fermented leaf characters.*

Name and strain number	Rough classification of fermented leaves						Total yield	Per cent wrappers	Computed yield per hectare
	Fine		Medium fine		Thick				
	Kilograms	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*		*Kilograms*
G×F5–14	2,68	20.97	1.440	11.26	8.660	67.77	12.780	32.23	1,418.5
G×F5–34	4.10	26.47	1.280	8.26	10.106	65.27	15.486	34.73	1,618.9
G×F5–48	2.82	22.42	1.310	10.41	8.448	67.17	12.578	32.83	1,387.1
G×F5–51	4.07	30.54	1.365	10.24	7.891	59.22	13.326	40.78	1,479.2
G×F5–56	3.03	18.80	1.000	6.20	12.085	75.00	16.115	25.00	1,788.7
I ×F5–1	3.59	18.59	2.750	13.72	12.976	67.69	19.320	32.31	2,144.5
I ×F5–2	3.30	25.53	2.310	17.79	7.314	56.68	12.930	43.32	1,437.4
I ×F5–3	4.89	24.02	1.115	5.43	14.350	70.55	20.350	29.45	2,258.8
I ×F5–5	4.77	18.85	2.760	10.94	17.770	70.21	25.300	29.79	2,608.3
I ×F5–21	3.38	16.95	2 500	12.53	14.063	70.52	19.940	29.48	2,213.3
H×F5–1							26.600	38.35	1,182.2
H×F5–16							28.300	34.65	1,257.7
H×F5–17							30.000	31.33	1,333.3

TABLE 5.—*Showing the average production per plot, completed yield per hectare, and fermented leaf characters*—Continued.

Name and strain number	Fermented leaf characters and qualities						
	General color of wrappers	Aroma	Color of ash	Burning quality seconds	Character of veins	Feature of leaf	Elasticity
G×F5–14	Light brown	Mild	Whitish gray	13.1	Med. fine	Fine	Very elastic.
G×F5–34	Fallow to light brown	do	Gray	20.0	do	do	Do.
G×F5–48	Light brown	do	do	15.4	do	do	Do.
G×F5–51	do	do	do	16.7	do	Fine–Med. fine	Do.
G×F5–56	do	do	do	8.8	do	Medium fine	Do.
I×F5–1	do	do	do	22.0	Fine	do	Do.
I×F5–2	do	do	do	25.2	Med. fine	Med. fine	Elastic.
I×F5–3	Fallow	do	do	28.0	Fine	Fine	Very elastic.
I×F5–5	Light brown to brown	do	Whitish gray	25.7	Prominent	Med. fine	Do.
I×F5–21	Light brown	do	Gray	33.4	do	do	Elastic.
H×F5–1	do	do	do	22.1	Fine	Fine	Do.
H×F5–16	do	do	do	16.1	do	do	Do.
H×F5–17	do	do	do	24.2	do	do	Do.

TABLE 6.—*Showing the summary of results of marketable classes of wrapper tobacco, the class sizes and the number of leaves per kilo of the strains tested.*

Name and strain number	Fallow (V)		Light brown (LB)		Multicolored (BBL)		Brown (B)		Other wrapper classes	
	Kilograms	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*	*Per cent*
G×F5–14	0.46	3.61	0.76	5.94	1.00	7.88	0.50	3.94	1.40	10.94
G×F5–34	0.88	5.69	1.34	8.65	0.97	6.26	0.45	2.90	1.74	11.23
G×F5–48	0.37	2.95	0.74	5.84	1.26	10.01	0.53	4.25	1.23	9.78
G×F5–51	0.83	6.22	0.83	6.22	1.38	10.36	0.42	3.13	1.98	14.85
G×F5–56	0.52	3.22	1.58	3.58	0.98	6.04	0.38	3.36	1.58	9.80
I×F5–1	0.22	1.10	1.08	5.46	2.30	11.80	0.63	3.24	2.11	10.71
I×F5–2	0.44	3.40	1.04	8.02	1.44	11.12	0.83	6.41	1.86	14.36
I×F5–3	2.14	5.59	1.42	5.50	1.58	7.76	0.28	1.37	1.88	9.23
I×F5–5	0.92	3.63	1.58	6.25	1.89	7.45	0.66	2.61	2.48	9.85
I×F5–21	0.38	1.94	1.21	6.01	1.20	6.05	1.09	5.46	2.00	10.02
H×F5–1	2.0	7.52	1.6	6.02	2.2	8.27	0.30	1.13	4.1	15.41
H×F5–16	1.8	6.36	1.3	4.60	2.3	8.13	0.30	1.06	4.1	14.48
H×F5–17	2.2	7.33	0.9	3.00	3.4	8.00	0.90	3.00	10.0	10.00

TABLE 6.—*Showing the summary of results of marketable classes of wrapper tobacco, the class sizes and the number of leaves per kilo of the strains tested*—Continued.

Name and strain number	Total wrappers		Total fillers		Class sizes		Average number of leaves per kilo	
					First (38–46 cm.)	Second (30–38 cm.)	First class	Second class
	Kilograms	*Per cent*	*Kilograms*	*Per cent*	*Per cent*	*Per cent*		
G×F5–14	4.12	32.31	6.66	67.69	72.1	27.9	216	253
G×F5–34	5.38	34.73	10.11	65.27	72.5	27.5	220	269
G×F5–48	4.13	32.83	8.45	67.17	63.6	36.4	216	290
G×F5–51	5.44	40.78	7.89	59.22	78.2	21.8	205	300
G×F5–56	4.06	25.00	12.08	75.00	70.9	17.1	208	264
I×F5–1	6.34	32.31	12.98	62.69	82.91	17.1	179	227
I×F5–2	5.61	43.31	7.34	56.69	49.9	50.1	195	253
I×F5–3	7.00	29.45	14.35	70.55	80.7	19.3	199	277
I×F5–5	7.53	29.79	17.77	70.21	77.6	22.4	172	226
I×F5–21	5.88	29.48	14.06	70.52	75.2	24.8	185	242
H×F5–1	10.20	38.35	16.40	61.65	62.5	37.5	221	260
H×F5–16	9.80	34.63	18.50	65.37	68.4	31.6	209	248
H×F5–17	16.40	31.33	20.60	68.67	69.2	30 8	205	242

of selection and those wanting in these particulars were discarded. In order to check the behavior and performance of each line in certain tests with these specific objects of the selection from the test rows, these characters and qualities should be compared item by item, stating whether they were confirmed, disproved or have shown better results in the strain tests than in the plant-to-the-row tests.

A. Wrapper yield—
Beyond expectation: GxF_5–51, HxF_5–16.
Confirmed by: GxF_5–14, –34; HxF_5–1; IxF_5–1, –2.
Disproved by: IxF_5–3, –5.

B. Near mosaic resistance—
Beyond expectation: IxF_5–5.
Confirmed by: IxF_5–3; HxF_5–1; –16, and –17. GxF_5–34 (the least attacked of the Gx-hybrid strains).

C. Uniformity of color in the leaf—
Confirmed by: GxF_5–14, –34, IxF_5–3.

D. High breadth index—
Beyond expectation: GxF_5–48.
Confirmed by: IxF_5–1, –2, and –5; HxF_5–17.

E. High leaf number—
Confirmed by: GxF_5–34; IxF_5–1; HxF_5–1, –16, –17.

F. High wrapper production index—
Not determined in strain tests.

G. Fineness of veins—
Confirmed by: IxF_5–3; HxF_5–17.
Disproved by: IxF_5–1.

H. Fallow color—
Beyond expectation: GxF_5–34, –51; HxF_5–1, –16, –17.
Confirmed by: IxF_5–3.

I. Elasticity and suppleness—
Confirmed by all strains.

J. and K. Medium and late wrapper strains were not determined in the strain tests.

L. Dual-purposes strains—
Confirmed by GxF_5–56; IxF_5–1, –3, –5, and –21.

M. Trueness to type or constancy—
Confirmed by all strains under test.

With the data above and taking the sum total of the predominating characteristics and qualities shown by the different strains, the relative value for wrapper of the strains of each hybrid may be stated in the order named as follows:

GxF_5–34, –14, –51, –48, and –56.
HxF_5–1, –16, –17.
IxF_5–3, –1, –2, –5, and –21.

SUMMARY

General.—1. This study presents the efforts of six years to improve the best native cigar filler variety, the Vizcaya, by hybridization with Sumatra strains and constant hybrids thereof as male parents, followed by line selection and strain tests in the direction of producing wrapper and dual-purpose strains.

2. The technique of tobacco hybridization is very simple. The subsequent isolation and purification of desirable lines is the more difficult, requiring time, skill, and continuity of efforts.

3. Out of the six different hybrids, three, with the Vizcaya as female parent, were found promising.

4. There were definite principal types; 6 in the Gx hybrid, 3 in the Hx hybrid, and 5 in the Ix hybrid, found in the F_2 and the succeeding generation.

5. In plot cultures of four of the segregating hybrids in the F_3 generation, the Gx hybrid was found to be the most productive. It was found that Hx hybrid was the most nearly resistant to mosaic disease.

6. As far as the writer is aware, this is the only work in this country of native—Sumatra hybrids that have been undertaken continuously for six years by the same worker with the definite object of producing distinct medium-sized Philippine wrapper leaves. This is an attempt to help solve the wrapper problem with the peculiar climatic and soil conditions and method of culture in the Cagayan Valley.

Plant-to-the-row test.—1. There were originally 88 selection of hybrids sown in seed beds during the F_4 generation. Frequent storms reduced this to 10 selections of the Gx hybrids, 5 of the Hx hybrid, and 11 of the Ix hybrid, which were run in duplicate test rows of 100 plants each.

2. There were considerable variations in types, character, quality, and some botanical morphologic characters in the test rows, as shown by complete data presented in Tables 1 and 2.

3. Attention is invited to the carrying of the selection in the fermented leaf of all the strains studied and the new data tentatively called "wrapper production index."

4. Five lines of the Gx hybrid consisting of 5 definite types, 3 lines of the Hx hybrid of only one type, and 6 lines of the Ix hybrid of 3 types (2 lines of each type), were selected for further strain tests. How these different selected lines responded to the eleven objects of selection are graphically shown in Table 3.

5. Of the selected lines, the following in the order named have the most desirable characters and qualities: GxF_4–34, –14, –56; HxF_4–1 (a mutant for high leaf number), –16; IxF_4–3, –1.

Strain tests.—1. All the strains tested are now constant and show remarkable uniformity of type within the strains. The strains differ in botanical, morphological characters and behavior and they should now be considered as distinct races or varieties.

2. They differ in their individual susceptibility to pests and diseases. Within the hybrid, the most nearly resistant to the mosaic disease are the Hx hybrid lines, especially HxF_5–1, followed by the IxF_5 hybrid strains.

3. From each hybrid, the best results, confirming the findings in the previous tests, in wrapper qualities were shown by GxF_5 –34; –14; HxF_5–1; –16; IxF_5–3, and –1. These can be distributed to planters for the commercial production of wrapper tobacco.

4. The culture to which these strains were subjected was a compromise between the elaborate wrapper, and filler, cultures, and it is to be expected that under the elaborate culture, these strains will give a better account of themselves. The strains showed high adaptability to Ilagan, Isabela, conditions.

5. Depending upon the method of culture, these six best strains of the three hybrids can be expected to produce a preponderance of a wrapper crop or for both wrapper and filler crops.

6. The original objects in making these crosses have been attained in some of these strains.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Field of Vizcaya plants, the female parent used in four hybrids. This is the native variety chosen for developing a native wrapper type.

2. Baker Sumatra plant. Baker Sumatra is the best wrapper Sumatra strain in the Philippines.

PLATE 2

FIG. 1. The row at the right shows the Ax–11 in line selection at Pikit, Cotabato, 1923–1924 season. The male parent of Vizcaya × Ax–11 or Fx hybrid.

2. Plant of the Bx–27, a pure line of the hybrid Florida Sumatra and Baker Sumatra. The male parent of the Vizcaya × Bx–27 or Gx hybrid.

PLATE 3

FIG. 1. The row at the left shows the Bx–27 while in line selection work at Pikit, Cotabato, 1923–24 season.

2. The method of bagging tobacco flowers for crossing, 1928–29 season. The bag is made of cheesecloth with 2 wire rings to have a cylindrical form, permitting sunlight to the flowers but not the access of insects.

PLATE 4

FIG. 1. Type A, a good wrapper type.

2. Type D, a good dual-purpose type, of the Gx F_2 hybrid.

3. The Gx F_3 hybrid in plot test.

PLATE 5

FIG. 1. The Hx F_3 hybrid in plot test, 1931–32 season.

2. The Ix F_3 hybrid in plot test, 1931–32 season.

3. The Kx F_3 hybrid in plot test, 1931–32 season.

PLATE 6

FIG. 1. Plant-to-the-row test with Gx F_4 hybrid. Note the variability shown by the different rows. Note also the uniformity of plants shown by some of the test rows, especially Rows 14, 34, 48, 51, and 56.

PLATE 7

FIG. 1. Plant-to-the-row test with Hx F_4 hybrid. Note the variability shown by the different rows. Note uniformity of plants in the rows as to height and flowering. Row 1 had not yet flowered when the photograph was taken.

PLATE 7—(Continued)

FIG. 2. Plant-to-the-row test with Ix F_4 hybrid. Note the variability shown by the test rows. Note also uniformity of plants shown by certain rows. Rows 1 and 5 had not yet flowered when the photograph was taken. Note the difference in size and width of the leaves of the plants of different rows.

PLATE 8

FIG. 1. Representative leaves of different strains of the Gx F_4 hybrid. Note difference in shape, size, width, venation, and apex.

2. Representative leaves of different strains of Ix F_4 hybrid. Note difference in shape, size, width, venation, and apex.

PLATE 9

FIG. 1. The GxF_4–34, a line that was selected for its many outstanding qualities and characters with leaves curing a uniformly rich light brown color. It does not have a high breadth index, its only defect. It is less attacked by the mosaic disease than other Gx hybrid selected strains.

2. The IxF_4–1, a line that was especially selected for the high breadth index of its leaves (62.2 ÷ 0.577%) and also the highest yielding strain. It bred true to type as shown by the great uniformity of its progeny. It has a high leaf number, high wrapper production index, with fine veins and good elasticity and suppleness. Being a late strain with large broad leaves, it can also be considered a dual-purpose strain.

PLATE 10

FIG. 1. The IxF_4–3, a line that produced the largest proportion of light fallow (aceitunado claro) colored leaves among all the strains under study, a character inherited from the American Sumatra, its male parent. It has the appearance of the Vizcaya, its female parent, but is superior to it in wrapper yield, near mosaic resistence, uniformity of color in the leaf, high wrapper production index, fineness of veins, elasticity and suppleness. It may be also considered a dual-purpose strain.

2. The IxF_4–5, the line that showed a beautiful field appearance, but was somewhat remiss in the fermented leaf results, proving the contention that selection must await the fermented leaf results. It has, however, high wrapper yield, high breadth index, bred true to type, and of late adaptability. An excellent dual-purpose strain with broader leaves than the Vizcaya, its female parent.

1

2

PLATE 1.

Ax 14
Ax-13
A x
SUMATRA FLORIDA
SUMATRA
Ax12
Ax11

1

Bx-27
Bx-
FLORIDA SUMATRA X SU
MATRA

2

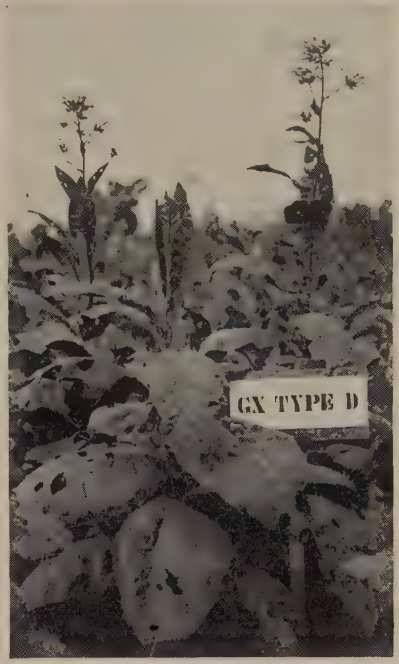
PLATE 2.

1

2

PLATE 3.

1



2

3

PLATE 4.

1

2

3

PLATE 5.

1

2

3

PLATE 6.

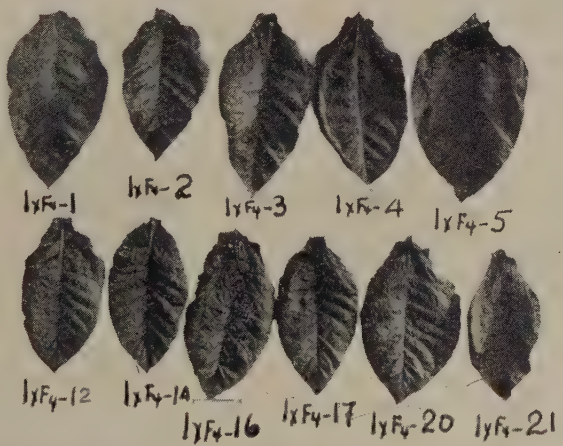
1

2

PLATE 7.

GxF4-14
GxF4-16
GxF4-19
GxF4-30
GxF4-34
GxF4-43
GxF4-48
GxF4-51
GxF4-55
GxF4-56

1


IxF4-1
IxF4-2
IxF4-3
IxF4-4
IxF4-5
IxF4-12
IxF4-14
IxF4-16
IxF4-17
IxF4-20
IxF4-21

2

PLATE 8.

1

2

PLATE 9.

1

2

PLATE 10.

A FIELD STUDY ON THE CITRUS GREEN BUG *RHYNCHOCORIS SERRATUS* DONOVAN

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FOUR PLATES

This insect, which belongs to the Family *Pentatomidae,* subfamily *Pentatominae,* Order *Hemiptera,* has been observed rather harmful to citrus fruits in the Philippines, causing them to fall off. In the orchard of Mr. Jose Alvarez, at Mailag, Bukidnon, it caused a loss in 1931 of from 30 to 40 per cent of the crop of sweet orange (cajel). At Novaliches, Caloocan, the insect caused a loss in 1933 of from 15 to 30 per cent of the mandarin and calamondin crops. The following varieties were found attacked by the bug at the Citrus Station at Tanauan, Batangas, the damage varying from 8 to 26 per cent of the crops:

1. Ruby orange
2. Majorca orange
3. Dougat orange
4. Du Roi orange
5. Pineapple orange
6. Batangas orange
7. Batangas mandarin

This insect was the subject of complaint to the Bureau of Agriculture, and later to the Bureau of Plant Industry, from growers in various parts of the Islands. In view of its seriousness, it was decided that a study be made of the life history, habits and the means of controlling the insect. The data presented in this paper were obtained at Novaliches, Caloocan, Rizal, in 1933 and 1934.

GEOGRAPHICAL DISTRIBUTION

The citrus green bug is apparently widely distributed in the Philippines. Besides the personal field observations of the writer, as already given, Merino (1928) reported it as having caused in that year the falling off of most of the fruits of oranges in an orchard at Sison, Pangasinan. According to De Leon (1932), this insect is commonly found in Luzon, Visayas, and

Mindanao and attacks the fruits of calamondin, mandarin, and sweet ranges, causing them to fall off.

In other countries, Distant (1902) reported that the insect is found at Malabar, British India, Malay Peninsula, Java, Sumatra, and Borneo.

The citrus green-bug causes the same type of injury as that by *Rhynchocoris humeralis* Thunb., which is found in Assam, as reported by McSwiney (1919), Mitra and Khonwir (1928) and Gupta (1928). According to Hoffmann (1928) *Rhynchocoris humeralis* is also found in China and is a pest of oranges there.

MANNER OF FEEDING AND NATURE OF INJURY

The manner of feeding of adult *Rhynchocoris serratus* was studied in cages in the laboratory at Novaliches. Repeated observations showed that this insect, without being disturbed, stayed on the fruits usually from 6 a. m. to 8 p. m. It was observed that while feeding, the insect remained motionless on the fruit holding its labium at right angle and then directing the mandibles into the fruit. After a few minutes the labium was placed in its ordinary position leaving the mandibles and maxillae in the tissues of the fruit. While the mandibles and maxillae were inside the fruit the insect moved its head up and down. This motion, perhaps, was for the purpose of locating the locules of the fruit and to place the mouth parts in position for sucking. The puncture is about one-half of a millimeter in diameter.

Injured fruits exhibited a light yellow color on the rind around the puncture. From two to five days thereafter, the fruits fell off. Most of the fruits attacked by the bug were about one to five centimeters in diameter. The mature fruits were found seldom attacked by this insect.

LIFE HISTORY AND DESCRIPTIONS

METHODS OF STUDY

Eight nymphs in the fifth instar were captured from the field and these were reared in a battery jar with fruits of calamondin and mandarin. The dates of their changing to the adult stage were recorded. Mating was then observed, and each pair in copula was placed separately in a battery jar (16 cm. diameter by 20 cm. high) and this covered with cheese cloth. The insects were kept supplied with fruits and fresh leaves of calamondin, mandarin, and cabuyao. Every day the food materials thus furnished were examined for eggs and the old ones

changed every three days. Each mass of eggs was kept in a separate container and labeled or given the number of its corresponding mother.

The newly emerged nymphs were reared on trees in celluloid cylinders 35 centimeters long and 15 centimeters in diameter (Plate 4, fig. 1). Both ends of each cylinder were fitted with cheesecloth. Fruits and leaves of calamondin and mandarin were enclosed in each cylinder and five nymphs were placed in each cage with them. The cylinder and the nymphs were transferred to fresh fruits when the old ones dropped.

EGGS

The eggs are laid on the upper surface of the leaf in groups of from 3 to 14. Each individual egg measures about 2 millimeters and is somewhat spherical, creamy white and smooth. Immediately before hatching it turns light yellow. The chorion is white and transparent.

NYMPH

There are five instars as follows, with their respective descriptions:

First instar.—Newly emerged nymph, about 3.5 millimeters long and 2.9 millimeters wide. Color mostly light yellow to orange.

Head black, over one-third the length of the whole body. Antennae black, five-segmented, about three times as long as head. Eyes somewhat hemispherical, reddish brown, set laterally at base of head. Labium concolorous with head, over two-thirds as long as body, four-segmented, all segments unequal in length.

Thorax black, about one-third as long as body; prothorax about twice the length of mesothorax; metathorax less than one-half as long as mesothorax.

Abdomen over one-third as long as body. Color orange. Black spots are present along marginal and mesal regions.

Second instar.—About 6 millimeters long and 4 millimeters wide just after first molting. Color mostly light orange.

Head, black and white at margin, about one-fourth the length of the body. Antennae five-segmented, about five times as long as head, with the last segment white and black at tip. Labium, extending to about middle of sixth abdominal segment; four segmented; all segments unequal in length.

Thorax black with white anterior margin. Length, about one-third that of body; prothorax about one-half total length

of thorax; mesothorax about one-half as long as prothorax; metathorax about one-half as long as mesothorax.

Abdomen, about one-third as long as body; color and markings as in first instar.

Third instar.—About 8 millimeters long and 6 millimeters wide just after second molting. Color light orange. Characters of head and the rest of the body similar to those of second instar.

Fourth instar.—About 12 millimeters long and 7.0 millimeters wide just after the third molting. Color mostly orange.

Head black with white anterior margin. Other characters similar to those preceding instar.

Fifth instar.—About 18 millimeters long and 10 millimeters wide just after the fourth molting. Color mostly orange.

Head, white along the margin and black at median. Labium about four times the length of head, four-segmented; extends to middle of sixth abdominal segment.

Thorax, over one-half whole body in length, prothorax, over one-third total length of thorax, mesothorax about five times as long as prothorax, metathorax about two times as long as mesothorax. Scutellum somewhat triangular, over nine times as long as body. Wing pads concolorous with body, extending to the third abdominal segment; length over four times that of body.

Abdomen, about one-half of body in length. Color, orange. Spots along margin somewhat crescent in shape and spots on mesal region as in the first to fourth instars.

ADULTS

Male.—Length, about 20 millimeters. Color, olive-green. Body thickly punctate.

Head subconical, about one-fifth total length of body. Antennae about three-fourths of body in length; five-segmented; all segments unequal in length. Labium, about three-fourths of body in length, extends to end of fifth abdominal segment.

Prothorax, about one-fourth whole body in length. Scutellum concolorous with body, somewhat triangular, about one and six-tenths of prothorax in length. Hemelytra about four-tenths longer than abdomen in length. Corium thick, finely punctate; membrane thin and membranous.

Abdomen, about one-half as long as body, length subequal to greatest width. Tergites, olive-green. Sternites, blue with olive-green margin. Spine, five at each margin. Genital seg-

ment somewhat rectangular, about one-half as long as the preceding segment. Spine none at both sides.

Female.—Length, about 24 millimeters. Caudal segment slightly broader than length. Spine present at both sides of abdominal segment preceding the anal segment. Other characters similar to male.

Rynchocoris serratus Don. (Cimex) was described in the Fauna of British India by Distant (1902) as follows:

> Olive-green or ochraceous; differing principally from the preceding species (*R. humeralis* Thunb.) by the lateral angles of the pronotum, which are slender, acutely pointed, their apices very slightly recurved, black, or very coarsely blacky punctate; lateral margins of the lateral lobe of head profoundly black; connexivum unspotted, the segmental angles only black.
>
> Length, 20–24; breadth between pronotal angles 16 to 18 millimeters.

OBSERVATIONS ON ADULTS

Under field conditions, the adults were observed to begin feeding on the fruits at about six o'clock in the morning. At noon time, when the day was hot, they were found to hide among the leaves. They resumed feeding in the afternoon, and without being disturbed, they stayed on the fruits until late in the evening.

COPULATION

Copulation was observed in the laboratory to take place in the morning. The sexes were observed to remain in copula from 4 to 48 hours during which they also fed. No pair was observed to go into copula in the afternoon. Only three copulations were observed during the lifetime of a couple. Table 1 gives a record of copulations of six pairs of adults under confinement in battery jars.

TABLE 1.—*Records of copulation*

Culture number	Date of emergence of female	Date of first copulation	Age of female	Date of last copulation	Intervals of first and last copulation
			Days		*Days*
1	21–VI–34	2–VII–34	11	30–VIII–34	59
4	25–VI–34	5–VII–34	10	21–IX–34	78
5	29–VI–34	8–VII–34	9	12–VIII–34	35
6	30–VI–34	24–VII–34	24	escaped	----------
37	23–VIII–34	4–IX–34	12	3–X–34	29
38	27–VIII–34	4–IX–34	8	20–IX–34	16

Average	12.5 days
Maximum	24 days
Minimum	8 days

From the preceding table, the first copulation took place when the females were 8 to 24 days old (that is, 8 to 24 days after emergence) with an average age of 12.5 days. The interval between the first copulation and last copulation is from 16 to 78, the average being 43.5 days.

OVIPOSITION

Oviposition was found to take place in the afternoon. When the female finds a suitable place it remains motionless, placing the end of its abdomen close to the leaf and after a few minutes an egg is laid. After an egg is laid, it rests for a few minutes before laying another egg. Table 2 gives the ages of some female insects before they laid their first eggs and the time of last egg-laying.

TABLE 2.—*Age of female at first and last egg-laying*

Culture number	Date of emergence	First oviposition		Last oviposition	
		Date	Days	Date	Days
1	21–VI–34	26–VII–34	35	4–X–34	105
4	25–VI–34	16–VII–34	21	26–IX–34	93
5	29–VI–34	19–VII–34	20	3–IX–34	66
6	30–VI–34	28–VII–34	28	escaped	
37	23–VIII–34	7–IX–34	15	5–X–34	43
38	27–VIII–34	6–IX–34	10	26–IX–34	30
38–a	23–VIII–34	18–IX–34	26	25–IX–34	33

Average age	22 days
Maximum age	35 days
Minimum age	10 days

From the preceding records, the ages of the female, when they commenced laying were from 10 to 35 days, the average being 22 days. The ages of the insects when they laid their last eggs were from 30 to 105 days, or an average of 61.6 days.

DAILY AND TOTAL RATE OF OVIPOSITION

Five couples were observed in the laboratory for egg-laying record. Table 3 gives the daily and total number of eggs laid by five females, each having been confined with a male.

As may be seen from the above table, the number of eggs laid by each individual female per day ranged from 3 to 14, or an average of 12.5 eggs per day. The total number of eggs laid were from 81 to 253, the average being 151.8 eggs for each female. These eggs were laid at intervals of 2 to 9 days.

TABLE 3.—*Daily records of eggs laid*

Number of oviposition	Culture No.				
	1	4	5	9	12
	Eggs	*Eggs*	*Eggs*	*Eggs*	*Eggs*
1	14	14	13	7	11
2	14	14	13	7	14
3	14	14	14	11	14
4	14	13	14	14	14
5	14	14	14	14	14
6	13	14	13	14	14
7	14	14	0	13	14
8	13	14	0	14	5
9	8	14	0	14	10
10	14	0		13	14
11	14	0		12	0
12	14	0		13	0
13	14			12	0
14	14			4	
15	14			14	
16	11			0	
17	11			0	
18	8			0	
19	3				
20	10				
21	8				

Average	12.5
Maximum	14
Minimum	3

TABLE 4.—*Incubation period*

Culture number	Date of egg laid	Date of hatching	Length of incubation period
			Days
2	22–VI–34	27–VI–34	5
7	28–VI–34	4–VII–34	6
9	12–VII–34	17–VII–34	5
10	19–VII–34	24–VII–34	5
11	22–VII–34	29–VII–34	7
12	24–VII–34	29–VII–34	5
13	31–VII–34	5–VIII–34	5
14	6–VIII–34	13–VIII–34	7
15	10–VIII–34	16–VIII–34	6
21	12–VIII–34	18–VIII–34	6
24	16–VIII–34	22–VIII–34	6

Average	5.72 days
Maximum	7
Minimum	5

TABLE 5.—*Duration of instar and total number of days of nymphal stage.*

	Culture No. 31		Culture No. 32		Culture No. 33		Culture No. 34	
	Date	Average number of days between moltings	Date	Average number of days between moltings	Date	Average number of days between moltings	Date	Average number of days between moltings
		Days		*Days*		*Days*		*Days*
Egg hatched	21–V–34		23–V–34		1–VI–34		27–VI–34	
First molt	26–V–34	5	27–V–34	4	6–VI–34	5	2–VII–34	5
Second molt	2–VI–34	7	2–VI–34	6	12–VI–34	6	7–VII–34	5
Third molt	7–VI–34	5	10–VI–34	8	18–VI–34	6	14–VII–34	7
Fourth molt	12–VI–34	5	15–VI–34	5	23–VI–34	5	21–VII–34	7
Fifth molt	21–VI–34	9	25–VI–34	10	3–VII–34	10	30–VII–34	9
Nymphal stage		31		33		32		33
	Culture No. 35		Culture No. 36		Culture No. 37		Culture No. 38	
Egg hatched	4–VII–34		17–VII–34		24–VII–34		29–VII–34	
First molt	8–VII–34	4	21–VII–34	4	27–VII–34	3	2–VIII–34	4
Second molt	13–VII–34	5	26–VII–34	5	4–VIII–34	8	7–VIII–34	5
Third molt	20–VII–34	7	2–VIII–34	7	11–VIII–34	7	13–VIII–34	6
Fourth molt	27–VII–34	7	11–VIII–34	9	16–VIII–34	5	21–VIII–34	8
Fifth molt	6 VIII–34	10	21–VIII–34	10	23–VIII–34	7	31–VIII–34	10
Nymphal stage		33		35		30		33

	Culture No. 41		Culture No. 42		Culture No. 43		Culture No. 44	
Egg hatched	3–VIII–34		5–VIII–34		5–VIII–34		13–VIII–34	
First molt	8–VIII–34	5	9–VIII–34	4	9–VIII–34	4	17–VIII–34	4
Second molt	15–VIII–34	7	15–VIII–34	6	15–VIII–34	6	23–VIII–34	6
Third molt	21–VIII–34	6	21–VIII–34	6	22–VIII–34	7	29–VIII–34	6
Fourth molt	27–VIII–34	6	27–VIII–34	6	S		3–IX–34	5
Fifth molt	6–IX–34	10	5–IX–34	9			13–IX–34	10
Nymphal stage		34		31				31

	Culture No. 45		Culture No. 46		Culture No. 47		Culture No. 48	
Egg hatched	15 VIII–34		16 VIII 34		16–VIII 34		18–VIII 34	
First molt	20–VIII–34	5	21–VIII–34	5	21–VIII–3	5	22–VIII–34	4
Second molt	26–VIII–34	6	28–VIII–34	7	26–VIII–34	5	27–VIII–34	5
Third molt	31–VIII–34	5	2–IX–34	5	31–VIII–34	5	3–IX–34	7
Fourth molt	7–IX–34	7	10–IX–34	8	8–IX–34	8	9–IX–34	6
Fifth molt	18–IX–34	11	20–IX–34	10	19–IX–34	11	20–IX–34	11
Nymphal stage		34		35		34		33

	Culture No. 49		Culture No. 50		Culture No. 51		Culture No. 52	
Egg hatched	17–VIII–34		21–VIII–34		22–VIII–34		28–VIII–34	
First molt	22–VIII–34	5	26–VIII–34	5	27–VIII–34	5	2–IX–34	5
Second molt	27–VIII–34	5	31–VIII–34	5	2–IX–34	6	8–IX–34	6
Third molt	2–IX–34	6	5–IX–34	5	7–IX–34	5	13–IX–34	5
Fourth molt	10–IX–34	8	10–IX–34	5	13–IX–34	6	19–IX–34	6
Fifth molt	20–IX–34	10	20–IX–34	10	23–IX–34	10	28–IX–34	9
Nymphal stage		34		30		32		31

INCUBATION PERIOD

Eggs in groups collected from the different cultures in the laboratory were used for determining the period of incubation. Table 4 gives the incubation period of the eggs of *R. serratus* under laboratory conditions.

From the table above, it will be seen that the incubation period of the eggs during the months of June, July, and August was from 5 to 7 days, with an average of 5.72 days.

DURATION OF NYMPHAL STAGE

The nymph passess through five instars. Table 5 shows the records of 18 sets of nymphs under observation.

From Table 5, it may be seen that the first instar lasted from 3 to 5 days; the second, 5 to 7; the third, 5 to 8; the fourth, 5 to 9; and fifth, 7 to 11 days, the average being 4.35 days for the first instar, 5.8 for the second, 6.05 for the third, 6.42 for the fourth, and 9.7 days for the fifth instar.

NYMPHAL HABITS

The first instar nymphs are gregarious and in the field were observed to stay chiefly on the leaves. At this stage they were found to subsist upon the sap of the leaves. After the first molt they migrated to the branches and searched for the fruits to feed. Feeding on the fruits took place between 7 to 9 o'clock in the morning. When they were not feeding they stayed among the leaves and resumed feeding in the afternoon.

SEASON OF ABUNDANCE

In 1933 and 1934, at Novaliches, Caloocan, Rizal, it was observed that the insect in all stages was abundant during the months of May to August; that is, the abundance coincided with the fruiting season. During these months considerable numbers of fruits fell due to the attack. The pest was found scarce during September, October, and November, as most of the fruits were maturing and unsuitable for the food of the bug.

FOOD PLANTS

Rhynchocoris serratus was found to confine its attack to the citrus family. It was noted that the cabuyao (Citrus hystrix), calamondin (*Citrus mitis* Blanco), lemon (*Citrus limonia* Osbeck), limes (*Citrus aurantifolia* Swingle) and cajel (*Citrus sinensis* Osbeck) are favorite host plants of this insect. The pummelo and king mandarin were observed resistant to the at-

tack. The reason, perhaps, is that the pummelos have thick rinds, and that the king mandarin has a tough and rough rind, which makes it difficult for the insect to suck the juice.

NATURAL ENEMIES

Two kinds of predators of this pest were observed in the field, one of them being a species of mantid, *Hierodula patellifera* Serv.[1] Another predator is the big red ant, *Oecophylla smaragdina,* which feeds on the nymph. It was found that with the presence of this ant in the tree, no bugs alighted on the fruits. McSwiney in Assam reported that *O. smaragdina* preyed upon *Rynchocoris* sp. In China, Hoffmann mentioned that the nymphs of *R. humeralis* are destroyed by a certain mantid. He also stated that the introduction of this predator in the orchard may help to reduce the pest. De Leon in his report, writing on citrus propagation in the Philippines, casually mentioned that the egg of *R. serratus* are parasitized by a certain small wasp. However, the writer has not reared any from eggs collected from the field at Novaliches during the abundance of this pest in June and July, 1934. Perhaps, egg parasites, if any, are scarce or are not found there, so that it may be worthwhile to introduce some from other localities.

CONTROL MEASURES

Catching by net.—In China, where *Rynchocoris humeralis* has been studied to some extent, the principal method recommended for the control of the pest is catching the nymphs and adults by means of hand nets. This method has been employed here for the control of *R. serratus.* In 1932, De Leon found that the numbers of nymphs and adults were minimized by catching them with cheesecloth nets with long handles, this method having been recommended by the former plant pest control division (now plant Sanitation Division).

Light traps.—Two light traps, consisting of lantern lamps (Dietz), each placed over a basin of water and little soap were tried at Novaliches during the abundance of the bugs in July and August. Although the traps were set for five nights no green bug adults were caught, indicating that the adults were negatively photographic to the kind of light used.

Insecticide.—A preliminary spray of soap solution showed good results in the control of the nymphs. The spray was pre-

[1] Identified from the Bureau of Science collections by Mr. Gervacio Bellosillo of the Bureau of Science.

pared according to Formula 1 and was tried on four mandarin trees infested with nymphs. The spraying was repeated at intervals of five days.

FORMULA 1

Chinese laundry soap	400 grams
Water (one petroleum canful)	20 liters

Observations made on four trees for about two weeks gave the result that the trees sprayed were freed from the nymphal infestation. The two unsprayed trees used as checks were found to lose about 12 per cent of the fruits.

The next spraying experiment was a combination of soap and nicotine sulphate. The spray was prepared according to Formula 2 and was tried on four mandarin trees infested with nymphs and adults. The spraying was done at intervals of five days as usual.

FORMULA 2

Chinese laundry soap	200 grams
Nicotine sulphate ("Black leaf 40")	40 cc.
Water (one petroleum canful)	20 liters

As a result of the spraying experiment on the four trees treated they were freed from the nymphs infestation after a period of about two weeks. The adults were also killed with this concentration. Two unsprayed trees used as checks suffered a loss of 14 per cent of the fruits. The two sprays produced no burning effect on the young fruits and foliage of the trees. The spraying outfits consisted of Gould's hand pump with 10-meters rubber hose and Bordeaux nozzle.

SUMMARY AND CONCLUSIONS

1. The citrus green bug, *Rhynchocoris serratus*, which belongs to the family Pentatomidae, subfamily Pentatominae, order *Hemiptera*, as a pest of citrus fruits in the Philippines has been found to cause considerable damage to citrus fruits in certain places in the Philippines.

2. The insect is apparently widely distributed in the Islands. In other countries it is found in British India, Malay Peninsula, Java, Sumatra, and Borneo.

3. The fruits injured by the bug becomes yellow around the punctures and from two to five days they dropped. Fruits found most susceptible were from one to five centimeters in diameter.

4. The eggs are about 2 millimeters in diameter and are laid in groups of 3 to 14 on the upper surface of the leaves. They

are creamy white when freshly laid and light yellow before hatching.

5. Egg-laying took place from 10 to 35 days after the emergence of the adult. The number of eggs laid by a female per day varied from 3 to 14 and the total number was from 66 to 253 or an average total of 157.8 eggs from each female.

6. The incubation period of the egg was from 5 to 7 days with an average of 5.72.

7. There are five instars, the first instar lasting from 3 to 5 days; the second, 5 to 8 days; the third, 5 to 8; the fourth, 5 to 9; and the fifth, 7 to 11 days, or an average of 4.35 days for the first instar; 5.8 for the second, 6.06 days for the third; 6.42 for the fourth, 9.7 days for the fifth. The life cycle from the time the eggs are laid to the time the nymph changes into adult is from 30 to 46 with an average of 33.04 days.

8. The first instar nymphs were found gregarious and fed upon the sap of the leaf. They dispersed after the first molting and they were found to stay mostly on the fruits to feed. When they were not feeding on the fruits they were seen among the leaves.

9. *R. serratus,* in all stages, was observed abundant during the months of June, July, and August, the abundance coinciding with the fruiting season. It is scarce from September to November.

10. Citrus is the only host plant observed in the course of this study. The following varieties were found most preferred: cabuyao (*Citrus hytrix*), calamondin (*Citrus mitis*), mandarin (*Citrus nobilis*), lemon (*Citrus limonia*), and lime (*Citrus aurantifolia*). The pummelo and king mandarin were observed resistant.

11. Two kinds of predators were found; namely, a mantid *Hierodula paterllifera* Serv., and the big red ant *Oecophylla smaragdina,* both preying on the nymphs.

12. The numbers of the nymphs and adults of *R. serratus* can be minimized by catching them with hand nets with long handle.

13. Light traps of Dietz lantern lamps did not attract any adults.

14. In this study, the citrus green bug was satisfactorily controlled by spraying at intervals of five days, with soap solution of two per cent strength; or with soap and nicotine sulphate, soap solution of the amount of soap being one per cent soap and *nicotine sulphate,* two-tenths per cent.

ACKNOWLEDGMENT

The writer wishes to thank Dr. Gonzalo Merino and Mr. F. Q. Otanes, chief and assistant chief, respectively, of the Plant Sanitation Division, Bureau of Plant Industry, for their helpful suggestions during the course of this investigation and for help and criticisms in the preparation of the manuscript.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Adult male.
2. Genital segment of male.
3. Adult female.
4. Genital segment of female.

PLATE 2

FIG. 1. Eggs.
2. First instar nymph.
3. Second instar nymph.
4. Third instar nymph.
5. Fourth instar nymph.
6. Fifth instar nymph.

PLATE 3

Fruits attacked by the bug.

PLATE 4

Cages used in the life history studies

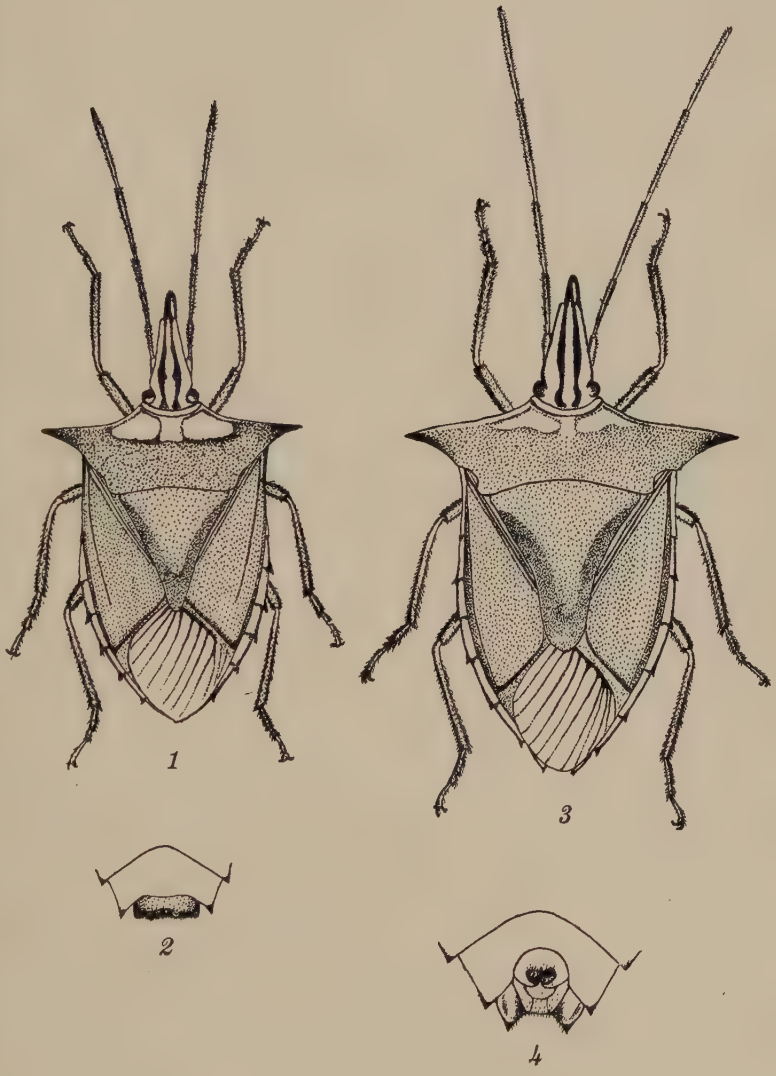

PLATE 1.

1

2

3

4

5

6

PLATE 2.

PLATE 3.

PLATE 4.

THREE BIRD CONTRIVANCES THAT ARE INDIRECTLY HARMFUL TO THE FILIPINO FARMERS[1]

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EIGHT PLATES

The willful destruction of some of our most beneficial birds through the use of air rifles, sling-shots and a bird trap known locally under the name of *bitag* or *bantay* (Tagalog), is figuratively "killing the goose that lays the golden egg." Apparently unaware of the consequences, countless number of boys even adult persons intentionally hunt song-birds with these contrivances for pastime. The harm thus done to our crops by these contrivances places them among the dangerous enemies of our farmers.

Because of the ravages of the contrivances, this study is undertaken to find out the food habits of the birds caught and killed by them. It is believed that this study would prove of value since the ravages of insects have always handicapped the farmers, and the Government has been spending thousands of pesos every year for pest control in an effort to aid the farmers in solving the world-wide problem of increasing production through increased yield per unit area. Moreover, no definite and systematic attempts have been made in this country to enhance the protection and to encourage the multiplication of birds which by far, are some of the most important natural enemies of insects. On the contrary, birds frequenting the farms have been persecuted since time immemorial.

METHODS OF STUDY

The foods of the different species of birds were determined by examining the stomach contents of materials collected in different places and at different periods. Some of the birds examined were collected by staff members of the former Section of Ornithology, principally by Mr. R. C. McGregor, dating back to 1904.

[1] Read before the Third Philippine Science Convention, February 26, 1935.

During the trips to the provinces around Manila (Laguna, Cavite, Batangas, Rizal, and Bulacan), the birds comprising the bags caught by air rifles and sling shots were noted. The names of the birds caught by *bantay* were suplied by the boys operating this trap. Occasionally, the traps were seen in action and the species of birds caught were noted.

In determining the food of birds, the volumetric method was used, i. e., the contents of the alimentary canal were considered 100 per cent by volume. The volume of the different food items were considered proportionately.

Owing to the fact that only a few stomachs were examined in some of the species of birds studied, the results herein indicated should not be considered conclusive. They are now presented merely to suspend the further destruction of beneficial birds and to create a sentiment against the use of these contrivances. Although these contrivances are obviously injurious, there is no way of obtaining quantitative estimate of the total destruction done by them.

RESULTS AND DISCUSSION

The birds caught by the three contrivances with the value of their stomach contents are given in Table 1. Stomach contents are termed injurious, neutral or beneficial depending on the importance of the group to which they belong.

Injurious food items consist mostly of larvae of insects, particularly caterpillars and grubs, and adults of grasshoppers and their allies (*Orthoptera*), termites (*Isoptera*), true bugs (*Hemiptera*), leaf hoppers and others (*Homoptera*), beetles (*Coleoptera*), flies (*Diptera*), and ants (*Formicidae, Hymenoptera*), etc. Weed seeds, fragments of wild fruits, and species of small crab are considered items of neutral importance, while spiders, dragon flies (*Odonata*), bees and wasps (*Hymenoptera*) commercial species of shrimp, crab and fish, are classified under beneficial food materials. When the percentage of the beneficial food items of a species exceeds that of the injurious items, the bird is considered injurious. Likewise a bird is regarded beneficial when its injurious food items exceed the beneficial. Rice seeds, however, may be considered both as neutral and beneficial food depending upon the way and place they were obtained. The barred ground doves were seen to pick rice seeds on the stubble(1), thus the item is considered of neutral importance, while Dussumier's turtle doves were noted to pick this material from the seed beds and in the hills where it is broad-

cast for planting. In the latter case the seeds are considered beneficial and the bird destructive.

One per cent of the food of the little yellow bittern studied consists of small locusts (*Acridiidæ*) while 90 per cent consists of shrimps (*Atyidae*), spider, dragon fly and fingerlings of dalag (*Ophicephalus striatus*).

Except Dussumier's turtle dove which was found to relish cockroaches and rice seeds, the food of five species of doves and pigeons studied comprised largely of wild fruits and weeds seeds.

The cuckoos are generally beneficial in their feeding habits and the red-winged coucal and the rufous-bellied cuckoo hold this reputation. The red-winged coucal had taken a small shrimp while one rufous-bellied cuckoo had small seeds of wild fruit in its stomach.

Fragments of a leaf-hopper and of a coconut flower were recovered from one Luzon colasisi. As this bird has oftentimes been condemned in coconut regions for its harmful effect on the fruit, the coconut flower obtained is considered beneficial and the bird is destructive in that item. Seeds of guavas were obtained from two guaiaberos examined. Of the three species of kingfishers studied the smallest (Asiatic kingfisher) is the most destructive, preying on small fishes. The white-collared kingfisher feeds on different insects to a large extent, and on miscellaneous beneficial animals, such as crab, house lizard, frog and fish to a less degree. Different kinds of beetles were obtained from nine white-throated kingfishers while in one, two small dalag (*Ophicephalus striatus*) were recovered.

The food of the black-naped flycatcher studied consists of ants, beetles, locusts and leaf-hoppers. Black and white fantail feed also on insects entirely.

In addition to destructive insects which comprise the greater percentage of the food of pied lalage, seeds of unrecognizable small fruits were also noted in the birds' stomachs studied.

The food of two species of bulbul (Philippine and guava) consists of wild fruits and insects. Fragments of both items were recovered from the stomachs of birds studied.

Dominico, pied chat and striated marsh warbler are insect-eating birds that are generally seen in or near the open field. Mosquitoes, locusts, beetles (larvae and adults), bugs, termites and seeds of cucurbitaceous plants were obtained from the stomachs of dominico studied. This bird, like the pied chat, frequents the edge of the open fields. Due perhaps to their

similarity in general habitat, the pied chat and the dominico have almost the same type of food. Except for a few weed seeds noted in one stomach of striated marsh warbler, its food consists wholly of insects. Open grasslands are favorite haunts of this species.

Our shrikes are very pugnacious, fighting fiercely other species of birds even much larger than themselves, as the hawk and the crow. They are very highly insectivorous, judging from the results obtained in this study. Various species of insect comprise the entire food of the white-bellied swallow shrikes examined. A few dragon flies and wasps were among those recovered. This species is among our most graceful insect-eating birds. They are often seen on telegraph lines in pairs or in small flocks of usually not more than ten birds. On trees, the birds prefer to stay on top so as to be able to see the surroundings for enemies and food materials which they swoop with peculiar gracefulness. They have been seen catching insects while flying.

Examination of stomachs revealed that various insects at different stages comprise the food of the Philippine red-tailed shrike(2). When they come to us in September, they immediately search the trees in our yards and gardens for insects. Decaying parts of trees are equally investigated for grubs and adult beetles, while twigs and leaves are examined for caterpillars, leaf hoppers and bugs. As they are very cheerful, especially during the first few weeks after their arrival, some people regard them as a nuisance.

The food of the large-nosed shrike, as revealed in the study of a few stomachs, is similar to that of the swallow shrike. Fragments of dragon flies and wasps were also recorded in a few stomachs of this bird as in the white-bellied swallow shrike.

Insects and fruits comprise the food of the Meyen's silver-eye. These birds were observed frequenting coconut trees. Although fragments of coconut flowers were found in some stomachs, it has not been ascertained whether they actually destroy the plant. Thus the plant materials noted in the stomachs of these birds are considered of neutral importance.

Indian pipit and Formosan skylark both feed on insects and seeds of weeds and rice. As the rice seeds were undoubtedly obtained from the ground after the harvest, judging from the the observed habits of these birds, this item is considered of neutral importance.

Based on the food of 15 birds studied, the mountain sparrow is more destructive than beneficial. The food consists of rice and weed seeds in addition to insects. Rice, however, comprises the greater percentage. These birds frequent rice fields when the grain is in head.

Philippine oriole and gray-backed coleto are known to subsist on wild fruits and examination of their stomach contents confirm this common belief. In addition to wild friuts, however, insects and fragments of papaya, (*Carica papaya*) were also noted in the food of the oriole.

TABLE 1.—*Examinatin of stomach contents of birds obtained with air rifle, sling shots and bantay.*

Common name	Scientific name	Number of birds examined	Stomach contents classified (not bird)		
			Injurious	Neutral	Beneficial
			Per cent	*Per cent*	*Per cent*
Little yellow bittern	*Ixobrychus sinensis*	6	1		99
Northern white-eared pigeon	*Phapitreron leucotis*	9		100	
Slender-billed cuckoo dove	*Macropygia tenuirostris*	1		100	
Indian bronze-winged dove	*Chalcophaps indica*	7		100	
Dussumier's turtle dove	*Streptopelia dussumieri*	15	16	69	15
Barred ground dove	*Geopelia striata*	305		100	
Red-winged coucal	*Centropus viridis*	12	98	2	
Rufous-bellied cuckoo	*Cacomantis merulinus*	8	96	4	
Luzon colasisi	*Loriculus philippensis*	1	50		50
Luzon guaiabero	*Bolbopsittacus lunulatus*	2			100
White-collared kingfisher	*Sauropatis chloris*	24	78		22
White-throated kingfisher	*Halcyon gularis*	10	90		10
Asiatic kingfisher	*Alcedo bengalensis*	4			100
Black-naped flycatcher	*Hypothymis occipitalis*	9	100		
Black and white fantail	*Rhipidura nigritorquis*	2	100		
Pied lalage	*Lalage niger*	6	73	27	
Philippine bulbul	*Iole gularis*	12	22	78	
Guava bulbul	*Pycnonotus goiavier*	16	13	73	14
Dominico	*Copsychus mindanensis*	13	92		8
Pied chat	*Pratincola caprata*	7	86		14
Striated marsh warbler	*Megalurus palustris*	10	98	2	
White-bellied swallow shrike	*Artamus leucorynchus*	50	92		8
Philippine red-tailed shrike	*Lanius lucionensis*	13	100		
Large-nosed shrike	*Lanius nasutus*	12	92		8
Meyen's silvereye	*Zosterops myeni*	6	60	40	
Indian pipit	*Anthus rufulus*	10	90	10	
Formosan skylark	*Alauda wattersi*	8	29	71	
Mountain sparrow	*Passer montanus*	15	10	34	56
Philippine oriole	*Oriolus acrorhynchus*	33	20	59	21
Gray-backed coleto	*Sarcops calvus*	5		100	
Chinese starling	*Aethiopsar cristatellus*	19	56	36	8

The food of Chinese starling or crested mynah is very similar to that of the oriole. Like the oriole and the coleto, the Chinese starling frequents trees obviously for food and shelter. In addition, however, this bird is often seen in pasture fields associating with carabaos. Stomach examinations did not confirm the common observation that this bird picks ticks, lice and other arthropods from the body of the carabao. This species oftentimes makes its home in ceiling of houses and other places close to human habitation.

THE CONTRIVANCES; THEIR EFFECTS

Air rifles.—Air rifles are quite common in the Islands. Several makes are used but the most prevalent seems to be the piston-rod air rifles of various models. These air rifles look like toy guns but in reality they are effective weapons for killing birds. The contrivance (Plate 1, fig. 1) has a simple mechanism consisting of a brass barrel about 600 mm. in length and 20 mm. inside diameter, surmounted by another much smaller barrel about 5 mm inside diameter, but having the same length. Both are supported on a wooden stock by a bolt and a nut. The bigger barrel contains the air pump and the air chamber, while the small barrel receives and expels the lead shots. The trigger connects with a valve that closes the air chamber when in position and opens it when pulled. The instantaneous release of the reserved air from the air chamber to the small barrel expels the lead shot placed at the base of the latter with great force. The gun, being dependent on air action becomes stronger or weaker depending on the number of times it is pumped before it is fired. Ordinarily, birds ranging from sunbirds to medium-sized doves fall easily with three pumpings of the piston rod. There are instances when the air rifles which ordinarily are single-shot models, are changed to repeaters (Plate 1 fig. 2) by means of ingenious devices added to the original construction. In this way, the efficiency of the rifle is greatly increased. There are also many instances when air rifles are made at home with factory-made guns as models.

Next in use to the piston-rod air rifles are the repeating pump-action air rifles (Plate 1, fig. 3), which in reality depend on spring action and not on air as the name suggests. The rifle is a miniature copy of a real pump-gun using spring for power instead of powder. Although not so powerful as the single-shot air rifle, it works havoc on our feathered friends.

Lever-action air-rifles (Plate 1, fig. 4) are also used by boys. These are high-power guns loaded with lead shots of various forms. Because they are very expensive, they are not common.

Aside from the three main types of air rifles described above, there are many other makes of air rifles in use which, although ineffective as hunting devices, contribute to the mortality of our birds.

The effects of air rifles becomes more serious when their users are taken into consideration. Usually, adult persons who can improve the mechanism of air rifles and who are familiar with the habits of birds operate these contrivances with great efficiency. As a result, there is very little chance for the hunted bird to escape death. Observation discloses that this is the most dangerous enemy of our insectivorous song birds. These birds are often encountered in thickets, grasslands, orchards and even in populated districts making them easy preys for the users of air rifles.

A survey made shows that all the birds named in Table 1 are caught with the use of air rifle.

The beneficial birds killed are:

1. Red-winged coucal.
2. Rufous-bellied cuckoo.
3. White-collared kingfisher.
4. White-throated kingfisher.
5. Black-naped flycatcher.
6. Black and white fantail.
7. Pied lalage.
8. Philippine bulbul.
9. Dominico.
10. Pied chat.
11. Striated marsh warbler.
12. White-bellied swallow shrike.
13. Philippine red-tailed shrike.
14. Large-nosed shrike.
15. Meyen's silvereye.
16. Indian pipit.
17. Formosan skylark.
18. Chinese starling.

The birds of neutral importance caught are:

1. Northern white-eared pigeon.
2. Slender-billed cuckoo dove.
3. Indian bronze-winged dove.
4. Dussumier's turtle dove.
5. Barred ground dove.
6. Luzon colasisi.
7. Guava bulbul.
8. Philippine oriole.
9. Gray-backed coleto.

THE HARMFUL BIRDS CAUGHT ARE

1. Little yellow bittern.
2. Luzon guaiabero.
3. Asiatic kingfisher.
4. Mountain sparrow.

In grouping the birds according to their importance, the harm wrought or the benefit derived from them are given an edge over their neutral effects. For example, the food of the Philippine bulbul consists of 22 per cent injurious insects and 78 per cent

wild fruits of neutral importance. Inasmuch as the insects are more important than the wild fruits in this respect the bird is thus classified as beneficial. The importance of birds that feed on injurious, neutral and beneficial foods is determined only according to the first and the third. Mountain sparrow falls under this category. When the difference in the percentage between these two items is slight the bird is considered neutral in importance. Dussumier's turtle dove, Luzon colasisi, guava bulbul and Philippine oriole fall under this group.

It should be noted that this arrangement is based upon the food of adult birds. The food of the young which in most species consist of wild seeds and larvae of insects are not considered. The aesthetic value of the birds, considered by many as important in the enumeration of benefits derived from them, was not taken into account. In the order of their occurence in the bag, the birds more commonly caught are:

1. Guava bulbul.
2. Philippine red-tailed shrike.
3. Philippine bulbul.
4. Barred ground dove.
5. Black and white fantail.
6. Pied lalage.
7. Philippine oriole.

The first three birds frequent the yard, so that they are easy preys. Because of the bigger and alleged better taste of the flesh of the barred ground dove, they are hunted in paddy fields and brush close to them. Black and white fantail and pied lalage are commonly met with in the thicket and are accidentally caught in pursuit of other birds. The Philippine oriole is generally rarer and warier than any of the other six birds, but its beautiful bright golden yellow color and its bigger size appeal to the contrivers who impatiently search for the bird.

Sling shot.—The sling shot, although a simple toy device, is an effective weapon in killing common birds. It consists of a handle and a strap. The handle is typically Y–shaped. Several materials are used for the handle, including wire of different sizes braided together, a piece of board made to fit, but generally forked twigs of heavy wood are cut to suit the desired size. When a twig is used, the bark is removed and the wood is dried. The strap is always of rubber band, the size of which depends upon the wish of the contriver. Pieces from blown-out interior tubes of automobile tires are very commonly used as straps of sling shots. Generally, each wing is 20 centimeters long by 1.5 centimeters wide by 0.2 or 0.3 centimeters thick. The two wings are joined by a piece of leather of convenient texture which holds the shot (Plate 2). The free ends of the

strap are then tied one against each end of the arms of the handle. Rubber band or cotton thread is used for tying. Pebbles of various sizes, trimmings of iron or steel and hardened mud moulded for the purpose are used for shots.

Sling shots are generally operated by boys between 7 and 15 years old. These boys romp along the roadside in the morning and in the afternoon. Studies reveal that sling shots are commoner in rural districts than in thickly populated communities. This is perhaps primarily due to the luxuriant vegetation and consequent abundance of bird life in the former. It was also observed that around the City of Manila boys play with their sling-shots more frequently during the period from September to December than during any other time of the year. This is because the red-tailed shrikes are cheerful and more abundant then. This species spends the winter in the Philippines. For a time the birds are silent owing to their wearisome flight from their summer home in North China, Korea, etc., but two or three days after their arrival, they begin to twitter and their cheerfulness results from the abundance of insects which comprise their entire food.

It is interesting to observe that of 234 boys seen in Rizal and Laguna provinces operating sling shots, 194 were attending elementary schools. This circumstance is explained by the ages of the boys operating the contrivance. It may thus be concluded that the killing of insect-eating birds through the use of sling shots may be stopped through the help of teachers and other authorities of the elementary schools. Measures along this direction are now in process.

A survey made to determine the birds killed through the use of sling shots reveal the following:

1. Philippine red-tailed shrike.
2. Guava bulbul.
3. Philippine bulbul.
4. Barred ground dove.
5. Pied lalage.
6. Black and white fantail.
7. White-bellied swallow shrike.
8. Pied chat.
9. Dominico.

It will be noted that sling-shots are less effective than air rifles in killing birds. The ease in making sling-shots and the enormous number of boys operating this contrivance are, however, important factors to consider in the number of insect-eating birds slaughtered. The status of the birds named above is indicated in Table 1. It will be seen that seven of the birds species feed on injurious insects and are thus classified as beneficial birds. No estimate of the total number of individual beneficial

birds slaughtered annually has been made, but it must be great enough to be of significance in the maintenance of the natural balance.

Bantay.—Mechanically, *bantay* is a slip-noose trap. Structurally, it consists of a stake, a spring and a catch peg (Plate 3). Bamboo ends of convenient length, generally about 2 meters long are used for stakes. Both ends are made pointed so that the smaller end sticks into the ground and the bigger one induces the bird to alight on the catch peg.

At about 80 centimeters from the free end of the stake, just above a node, a hole is made on one side. This hole is used for the insertion of one end of a flexible bamboo twig which serves as the spring of the contrivance. In order that the stake could hold the spring very well and the spring could exert a great force, the butt of the spring is inserted toward the upper end of the joint until it nearly reaches the adjoining node. The whole length of the joint is thus nearly occupied by the butt of the spring. The other end of the spring is connected to a string provided with a loop at the other end. About 5 centimeters and immediately below the top of the pointed end of the stake, a hole 0.5 centimeter is drilled. The small end of the catch peg and the string are inserted in this hole. The loop which acts as the noose of the trap is set on the catch peg. The catch peg is a sub-bamboo stick about 12 centimeters long and 1 centimeter in its greatest diameter. This serves as the release.

This contrivance is generally operated in an open field and is called *bantay* which literally means guard. The name is probably derived from the fact that the trap stands prominently in the middle of the field as a sentinel. It catches any bird that rests on the catch peg, although it is intended for perching birds only. When a bird perches on the catch peg, the peg is released downward and the loop which is pulled by the spring catches the legs of the birds.

Boys pasturing carabaos usually operate this trap. Some boys operate *bantay* in an open field not far from their house, when they cannot afford a regular inspection of their traps, so that other boys might not molest their contrivance.

There is every reason to believe that this type of snare is intended primarily for the Philippine red-tailed shrike. In the months of September, October and November each year, *bantay* is a comomn sight, particularly in rural districts. It will be noted that this is the period of greatest abundance of the red-tailed shrike. Consequently, this bird comprises the larger per-

centage of the catch of this trap. Observation indicates that the following birds, in the order of their frequency, are caught with the use of *bantay:*

1. Philippine red-tailed shrike.
2. Large-nosed shrike.
3. Striated marsh warbler.
4. White-bellied swallow shrike.
5. Pied chat.
6. Dominico.

It will be seen that only few species of birds are caught with the use of *bantay.* The list, however, shows that all birds caught with it are insectivorous. The number of bird traps in operation and the total number of birds caught by these traps are important in estimating the value of the snare. Unfortunately, there is no way to obtain the figures. Basing the conclusion on the food habits of the species caught, this contrivance is clearly injurious.

SUMMARY

1. Two courses of investigation were followed in this study, viz; (*a*) observation of the bags of air rifles, sling shots and *bantay* and (*b*) determination of the economic value of these birds based on examination of their stomach contents.

2. The birds are considered injurious, if their diet includes a greater percentage of beneficial food items than harmful foods. Birds are classified as beneficial when their injurious foods outbalance the beneficial items. When their foods are of neutral importance, or when the beneficial items nearly balance the harmful items, the species are considered of neutral value.

3. Determination of the value of the birds was based on volumetric measurements of their stomach contents.

4. The results obtained are qualitative rather than quantitative. Necessary data to estimate the numerical value of the status of the birds are impossible to obtain.

5. The economic value of the insect food items which determines the status of birds is based mainly upon the importance of the group to which the insects belong.

6. The results are presented primarily to suspend further destruction of beneficial birds and to create sentiment against the use of air rifles, sling-shots and *bantay.*

7. Different makes of air rifles are used but the piston-rod air rifle is the most prevalent in the Philippines. Single-shot piston-rod air rifles are sometimes transformed into repeating piston-rod air rifles. Other types in common use are repeating pump-action air rifles and lever-action air rifles.

8. Adults who are able to enhance the slaughtering effects of air rifles, through modification of the contrivance and through their knowledge of the habits of birds, operate them.

9. A survey made to determine the birds caught with the use of air rifles indicate that 18 species are beneficial, 9 are of neutral importance while 4 are injurious.

10. Among the 7 species of birds frequently caught with the use of air rifles, 4 are beneficial and 3 are of neutral importance.

11. Sling-shots are generally operated by boys between 7 and 15 years of age.

12. Sling shots are commoner in rural districts than in more thickly populated communities. Around the City of Manila, boys with sling-shots are more frequently seen during 4 months (September to December) than in other periods. During these months, the Philippine red-tailed shrikes are in greatest abundance.

13. About 80 per cent of the boys encountered with sling-shots in Rizal and Laguna Provinces are attending public elementary schools.

14. The bags of sling-shot studied were found to consist of 9 species of birds. Of this number, 7 are considered beneficial. The ease in making sling-shots and the enormous number of boys operating this contrivance are important factors to consider in the destruction of insect-eating birds.

15. *Bantay* or *bitag* is a slip-noose type of bird trap. It is generally operated in an open field.

16. Boys pasturing carabaos are the common operators of *bantay*.

17. Indications tend to show that *bantay* is intended primarily for the Philippine red-tailed shrike.

18. Although the red-tailed shrike comprises the larger percentage of the catch of *bantay*, 5 other highly insectivorous birds are noted to comprise the bag of this snare.

19. No concrete data on the destructiveness of *bantay* are presented as there was no way of obtaining the number of birds caught. Based on the food habits of the species recorded, this contrivance is clearly injurious.

This study indicates that the birds frequently caught with the use of air rifles, sling shots and *bantay*, are highly insectivorous and should, therefore, be regarded as friends of our farmers. It also shows that the contrivances used for slaughtering these creatures are highly destructive and are thus dangerous to the farmers.

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ILLUSTRATIONS

PLATE 1

Various types of air rifle used for hunting wild birds in the Philippines.
FIG. 1. Piston-rod; single shot.
2. Piston-rod; repeater.
3. Pump-action; repeater.
4. Lever-action; single shot.

PLATE 2

A sling shot. Natural size. (Drawn by G. Ordonez)

PLATE 3

Bantay or *bitag*, a slip-noose type of bird trap. Approximately 1/10 its natural size. (Drawn by G. Ordonez)

PLATE 4

White-throated kingfisher; tigmamanoc, matang pescador (Tagalog); tugareng (Ilocano); salaksakan (Ilongo).

PLATE 5

FIG. 1. Black-naped flycatcher; pipit azul (Tag.).
2. Black and white fantail; maria capra (Tag.); salsal la pingao (Ilocano).

PLATE 6

FIG. 1. Pied chat; sipaó (Tag.).
2. Striated marsh warbler; tintirioc, sunod calabao (Tag.).

PLATE 7

FIG. 1. White-bellied swallow shrike; pagatpat (Tag.); gigit (Pampango); gikgik (Ilocano and Ilongo).
2. Philippine red-tailed shrike; tarat, pakiskis, cabezote (Tag.); tarat (Pampango); palal (Ilocano); gikgik (Ilongo).

PLATE 8

FIG. 1. Large-nosed shrike; tarat San Diego (Tag.); palal (Ilocano).
2. Chinese starling; martinez (Ilocano, Pampango and Tagalog).

PLATE 1.

PLATE 2.

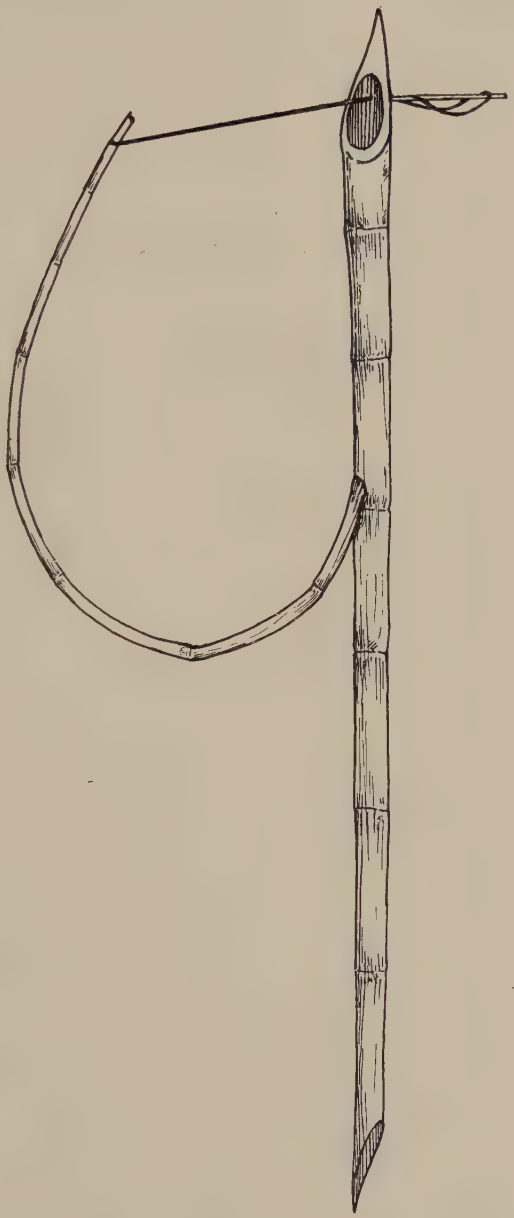

PLATE 3.

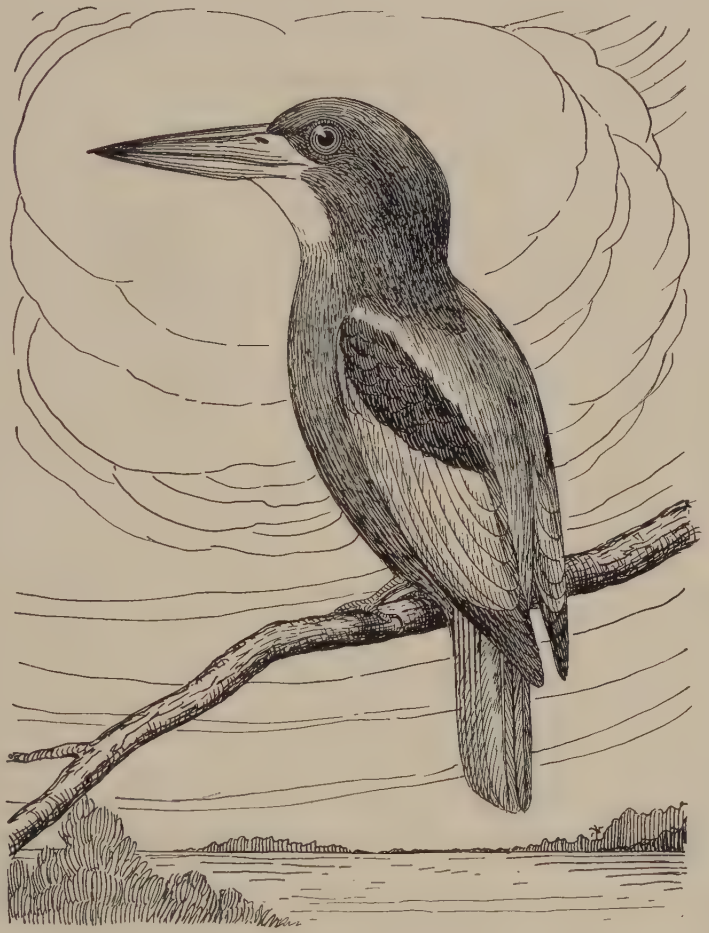

PLATE 4.

PLATE 5.

1

2

PLATE 6.

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PLATE 7.

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PLATE 8.

LONGEVITY OF SOME FARM CROP SEEDS

By PEDRO A. RODRIGO

Of the Horticulture Section, Bureau of Plant Industry

The duration of the life in a seed depends upon several factors. The more important of these factors are the degree of maturity at harvest; the method of gathering and curing the seed; the water content of the seed when stored; the composition of the seed; the nature of the seed coat; the method of storage; and the humidity and temperature of the air in the storing receptacle.

The proper storing of farm and garden seeds for planting has always been a vital problem to the farmer and the seed dealer. This is especially so in the Philippines because the moisture and temperature conditions throughout the year are conducive to rapid deterioration of seeds. The methods employed by our farmers and seed dealers in storing their seeds hardly exclude air, moisture, insect or fungus diseases. Imported seeds from temperate countries, particularly vegetable seeds, have been found to deteriorate in vitality very rapidly. An understanding of the factors affecting the longevity of seeds in storage is important not only to the farmers and seed dealers but also to scientists. It enables one to preserve seeds in quantities and to keep the purity of selected varieties and strains, especially of those which are given out for propagation and for commercial planting. It also enables a research worker who is testing a large number of varieties and strains, under limited means, to store part of his materials for experiment later on.

REVIEW OF LITERATURE

Several studies on the longevity of seeds have been undertaken in temperate countries. Most of these studies relate to herbarium specimens, excavated seeds and buried seeds. They include both wild and domesticated plants and attempt to determine the factors affecting the life in the seeds. Although such studies, especially those dealing with seeds of cultivated plants, should prove of great practical value in tropical countries, particularly in the Philippines, they have not as yet received due attention from research workers here.

295183——8

How long seeds are capable of remaining viable has always been an interesting question. Some impressions have prevailed that seeds are able to retain their vitality for long periods even if buried in the soil. The desire to check such impressions prompted Ewart and White (1908) to test for germination many herbarium samples of seeds of known age. These researchers found that many of the seeds which germinated were over 100 years. Ohga (1923), in a recent work on the germinative power of excavated seeds of *Nelumbo nucifera* in Manchuria, estimated its longevity to be 120 years or more.

The first attempt to obtain definite data on the length of time seeds are able to retain their vitality while buried in the soil so far as the writer is aware was made by Dr. W. J. Beal, of the Michigan Agricultural College in 1879. He buried at East Lansing, Michigan, 20 inverted open-mouth bottles, every bottle containing 50 seeds of each of 20 species. One bottle was taken up every 5 years. The last available report (1922) was made after 40 years, at which time 10 of the 20 species produced sprouts when tested. In 1902, according to Goss (1925), Dr. J. Duvel, of the Seed Laboratory of the U. S. Department of Agriculture, started the buried seeds experiment, following the general plan of Dr. Beal, but he used seeds of a larger number of species and subjected them to more natural conditions. He used 112 samples of seeds, representing 107 species. After one year he found that seeds of domesticated plants failed to germinate. Seeds of wild plants, however, were still capable of germination, the percentage of germination varying from a few per cent to over 50 per cent. The seeds which were buried deeper showed stronger vitality.

About 22 years later, Goss (1925) made a report of Dr. Duvel's experiment on buried seeds. He found out that "of the 107 species buried in 1902, 71 grew in 1903 after one year; 61 grew in 1905 after three years; 68 grew in 1908 after 6 years; 69 grew in 1912 after 10 years; 50 grew in 1918 after 16 years; and 51 grew in 1923 after 20 years."

On the causes of loss in the vitality of seeds Duvel (1904) conducted a series of studies. This was started in 1899 in the University of Michigan and was continued in the Seed Laboratory of the U. S. Department of Agriculture. The part of his findings that may be of immediate interest may be briefly summarized as follows: (1) That there was a close relationship between the precipitation and the loss in vitality in seed. The deterioration was more apparent with an increase in temperature,

but the injury caused by the increase in temperature was dependent upon the amount of moisture present. (2) The seeds which were exposed in a moist atmosphere to the higher temperature (36–37° C.) were killed much earlier than those subjected to the moist atmosphere at lower temperatures (30–32° C.) But, even at these lower temperatures, the deterioration of viability was comparatively rapid. Comparatively moist seeds in sealed bottles lost their viability sooner and more rapidly. (3) The seeds when kept dry were not injured by prolonged exposures to temperature below 37° C. whether in open or sealed containers. (4) The viability of seeds not well dried was better maintained at temperature just above freezing point, provided the temperature remained constant.

OBJECT OF THE STUDY

The original object of this study was to find an economical and practical way of storing farm crop seeds under Philippine conditions. Incidentally, the longevity of the seeds under different methods of storing was determined.

HISTORY

This study was started at the Los Baños College of Agriculture in January, 1924. The work was planned by Doctor Vibar [1] and the writer, and for the first five years the work was undertaken in the laboratory of the Division of Farm Crops, College of Agriculture, U. P. These results were published in the Proceedings of the Third Pan-Pacific Science Congress in Tokyo in 1926, and later in the *Philippine Agricultural Review* Vol. 22, No. 2, in 1929.

When the writer left the College of Agriculture in the early part of 1929, he deemed it wise to get one-half of the materials under study so as to insure the continuance of the work. These seeds were brought to Manila, to the Central Luzon Agricultural School, Muñoz, Nueva Ecija, to the Baguio Semi-temperate Fruit Station, Baguio, Benguet, and finally to the Central Experiment Station, Bureau of Plant Industry where the work is still in progress. New seeds, particularly vegetables, have been lately added to the materials under study. The seeds were tested in the different places at three months intervals except as indicated in the results.

[1] Toribio Vibar, formerly Assistant Professor in Agronomy, U. P., and Chief Agronomist, Bureau of Plant Industry, now Editor of "Agricultural Life."

From April 15, 1929, to June 15, 1929, the test should have been done in Manila but no determination was made. From September 20, 1929, to September 20, 1930, the germination tests were made in the Central Luzon Agricultural School, Muñoz, Nueva Ecija; while from November 5, 1930, to August 5, 1932, the tests were made at the Baguio Semi-temperate Fruit Station, Baguio. From September 21, 1932, up to the present, the germination tests have been performed at the Central Experiment Station, Bureau of Plant Industry, Manila. The seeds were kept under ordinary room temperature.

MATERIALS AND METHODS

The different seeds used in this study, together with the date when they were harvested and stored, are presented in Table 1.

TABLE 1.—*A list of the seeds used, with the date of harvesting and of storing.*

Kind of seed	Date harvested	Date stored
Rice (*Oryza sativa*):		
Inintiw	Jan. 15, 1924	Mar. 12, 1924
Hambas	Jan. 15, 1924	Mar. 12, 1924
Corn (*Zea Mays*):		
Calauan Yellow Flint	Feb. 9, 1924	Mar. 12, 1924
Moro	Feb. 15, 1924	Mar. 12, 1924
Australian Yellow Dent	Feb. 12, 1924	Mar. 12, 1924
Mungo (*Phaseolus aureus*):		
Dull Yellow	Mar. 7, 1924	Mar. 12, 1924
Cowpea (*Vigna sinensis*):		
New Era	Mar. 5, 1924	Mar. 12, 1924
Tapilan (*Phaseolus calcaratus*):		
Black	Feb. 15, 1924	Mar. 12, 1934
Yellow	Jan. 23, 1924	Mar. 12, 1924

Before storing, the seeds were first dried on a cement floor until they no longer lost in weight. This drying required from three to six days varying with the different kinds of seeds. This was done on the belief that air-dry seed would not lose moisture when stored in sealed container under ordinary room conditions and on the strength of the findings of Harrington and Crocker (1918) "that the percentage of germination was not materially changed when seed of wheat, barley, Sudan grass, Kentucky bluegrass and Johnson grass was dried to less than 1 per cent of moisture." The seeds were stored under three sets of conditions:

(1) in sealed containers; (2) in sealed containers with naphthalene; and (3) in cloth bag. With every test made, the sample was drawn from the containers after which the sealed containers were again made air-tight. Ordinary garden soil put in boxes was used as germinating medium. Only seeds that were able to send their plumules out of the soil were considered germinated.

RESULTS AND DISCUSSION

While the experiment was started in 1924, the data here presented were only those obtained from 1928 up to June 21, 1935. The study is still in progress.

Tables 2 and 3 present the results obtained from the rice and corn samples, respectively, while Table 4 gives similar data obtained from legume seeds.

TABLE 2.—*Showing the longevity of rice seeds under different methods of storing.*

Date tested	Age of seed from date of storing	Variety Hambas		Variety Inintiw	
		Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed
1924	*Month*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
April 2		[a] 97		[a] 98	
1928					
October 15	55	60	80	80	92
December 15	57	72	76	60	84
1929					
February 15	59	64	56	48	84
April 15	61				
June 15	63				
September 20	66	56	48	40	76
December 20	69	48	44	32	68
1930					
March 20	72	20	16	12	48
June 20	75	8	12	0	36
September 20	78				
November 5	79.5	0	4	4	16
1931					
February 5	82.5	0	0	0	12
May 5	85.5	0	0	0	4
August 5	88.5			0	0
November 5	91.5				0

[a] Initial.

TABLE 3.—*Showing the longevity of corn seeds under different methods of storing.*

Date tested	Age of seed from date of storing	Calauan Yellow Flint		Moro		Australian Yellow Dent	
		Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed
1924	*Month*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
March 15		[a] 100		[a] 100		[a] 100	
1928							
October 15	55	44	36	0	20	0	92
December 15	57	36	32	4	12	0	92
1929							
February 15	59	40	28	0	0	4	64
April 15	61						
June 15	63						
September 20	66	32	24	0	0	0	52
December 20	69	32	20	0	0	0	44
1930							
March 20	72	24	8				32
June 20	75	12	0				32
September 20	78						
November 5	79.5	0	0				4
1931							
February 5	82.5	0	0				0
May 5	85.5	0					0
August 5	88.8						0

[a] Initial.

TABLE 4.—*Showing the longevity of some leguminous seeds under different methods of storing.*

Date tested	Age of seed from date of storing	Cowpea		Mungo		
		Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed	Cloth bag
	Month	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1924						
March 15		[a]99		[a]100		
1928						
October 15	55	96	88	88	92	32
December 15	57	88	76	100	96	0
1929						
February 15	59	80	68	92	88	0
April 15	61					
June 15	63					
September 20	66	84	80	96	88	0
December 20	69	88	88	92	92	0
1930						
March 20	72	88	84	88	92	
June 20	75	80	84	88	88	
September 20	78					
November 5	79.5	76	76	92	84	
1931						
February 5	82.5	80	84	92	84	
May 5	85.5	80	88	92	80	
August 5	88.5	76	68	84	84	
November 5	91.5	72	52	76	88	
1932						
February 5	94.5	76	64	88	84	
May 5	97.5	72	60	88	92	
August 5	100.5	52	44	84	76	
September 21	102	36	56	84	68	
December 21	105	36	80	92	80	
1933						
March 21	108	8	64	92	84	
June 21	111	3	30	97	60	
September 21	114	0	12	84	48	
December 21	117	0	8	100	36	
1934						
March 21	120	0	8	92	36	
June 21	123	0	0	88	32	
September 21	126	0	0	84	24	
December 21	129		0	92	28	
1935						
March 21	132			88	24	
June 21	135			85	11	

[a] Initial.

TABLE 4.—*Showing the longevity of some leguminous seeds under different methods of storing*—Continued.

Date tested	Age of seed from date of storing	White Tapilan		Black Tapilan		
		Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed	Cloth bag
1924	*Month*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
March 15		[a] 96		[a] 80		
1928						
October 15	55	64	76	48	80	40
December 15	57	68	48	60	44	28
1929						
February 15	59	80	52	64	60	16
April 15	61					
June 15	63					
September 20	66	76	64	72	68	28
December 20	69	76	68	76	76	28
1930						
March 20	72	72	72	84	80	24
June 20	75	76	64	88	80	16
September 20	78					
November 5	79.5	72	68	84	88	20
1931						
February 5	82.5	68	72	88	84	16
May 5	85.5	68	68	88	80	20
August 5	88.5	60	64	92	84	20
November 5	91.5	56	56	76	92	24
1932						
February 5	94.5	72	56	84	92	20
May 5	97.5	64	44	84	92	24
August 5	100.5	64	12	68	88	24
September 21	102	32	16	76	88	16
December 21	105	48	28	96	80	28
1933						
March 21	108	60	28	92	96	24
June 21	111	30	12	90	93	33
September 21	114	16	20	92	88	32
December 21	117	20	16	80	92	20
1934						
March 21	120	24	12	84	88	36
June 21	123	28	0	80	72	12
September 21	126	16	0	84	72	20
December 21	129	20	4	84	80	16
1935						
March 21	132	4	8	72	72	24
June 21	135	12	4	68	88	12

[a] Initial.

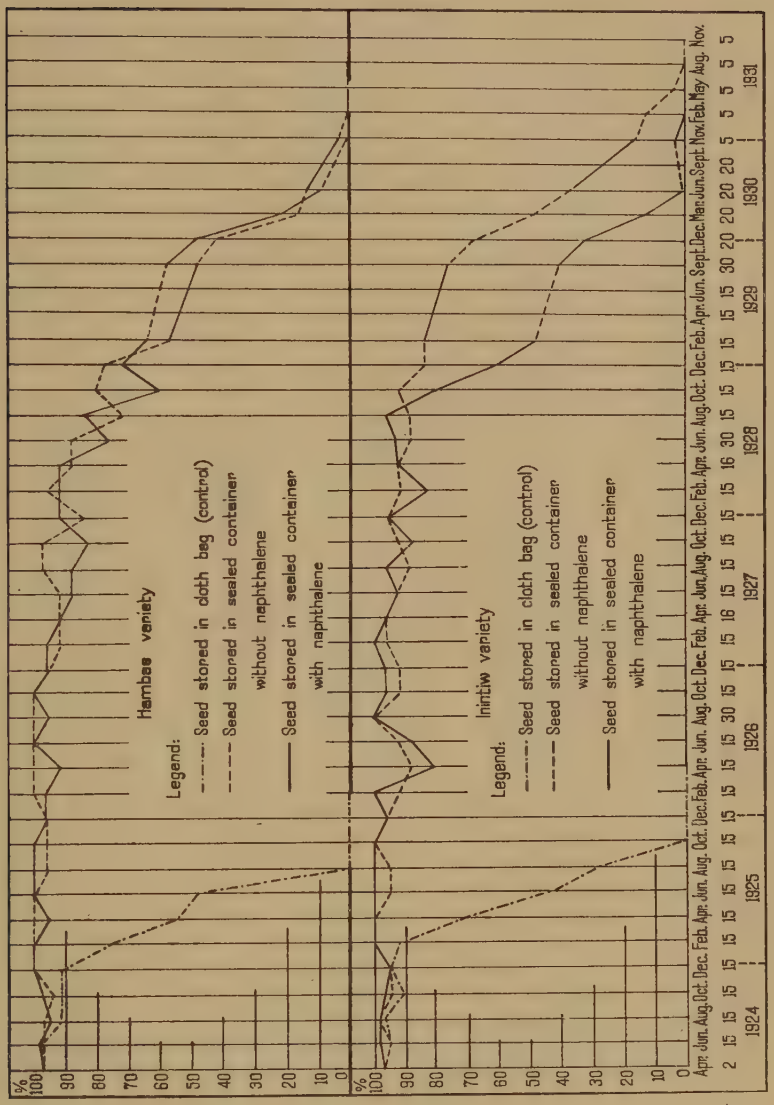
Hambas variety
Legend:
Seed stored in cloth bag (control)
Seed stored in sealed container without naphthalene
Seed stored in sealed container with naphthalene
Intiw variety
Legend:
Seed stored in cloth bag (control)
Seed stored in sealed container without naphthalene
Seed stored in sealed container with naphthalene
%
100
90
80
70
60
50
40
30
20
10
0
Apr. Jun. Aug. Oct. Dec. Feb. Apr. Jun. Aug. Oct. Dec. Feb. Apr. Jun. Aug. Oct. Dec. Feb. Apr. Jun. Aug. Oct. Dec. Feb. Apr. Jun. Aug. Oct. Dec. Feb. Apr. Jun. Aug. Oct. Dec. Feb. Apr. Jun. Aug. Oct. Dec. Feb. Apr. Jun. Aug. Oct. Dec. Feb. May Aug. Nov.
2 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 5 5 5 5 5
1924 1925 1926 1927 1928 1929 1930 1931

CHART 1. Showing the march of germination of rice seed stored under three sets of condition.

It will be noticed in Tables 2 and 3 that all the rice and corn seeds have already completely lost their viability, whereas in Table 4 it will be seen that some of the legumes like *Phaseolus calcaratus* (tapilan) and mungo were still maintaining a high percentage of germination when tested on June 21, 1935, exactly eleven years and three months after the experiment was started. The legume seeds, as a whole, remained viable for a longer period under the same conditions of storage than is the case of cereal

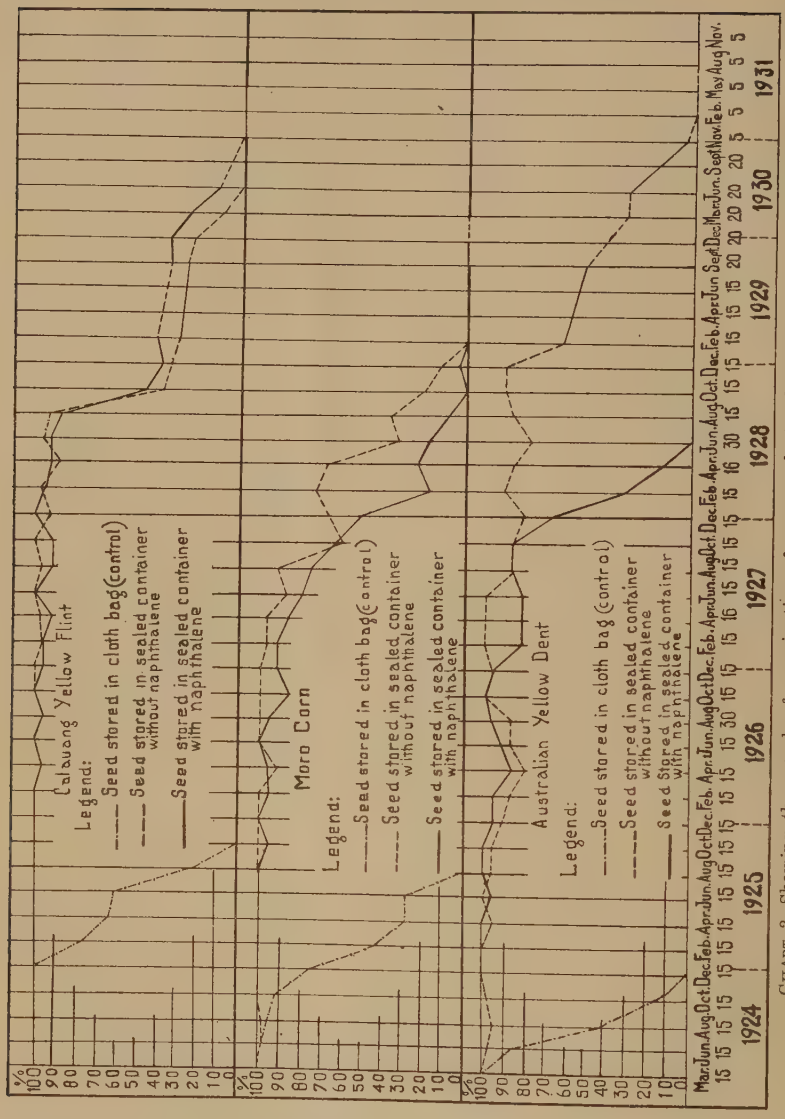

CHART 2. Showing the march of germination of corn seed stored under three sets of condition.

seeds. Oily legumes like peanut and soybean, however, lost their viability very much sooner than cereal seeds.

As seen in Tables 2, 3 and 4 and very well illustrated in graphs Nos. 1 to 4, the seeds stored in sealed containers either with or without naphthalene had very much longer span of life than the control. The seeds that were used as control (stored in non-air-tight containers) with the exception of tapilan (black

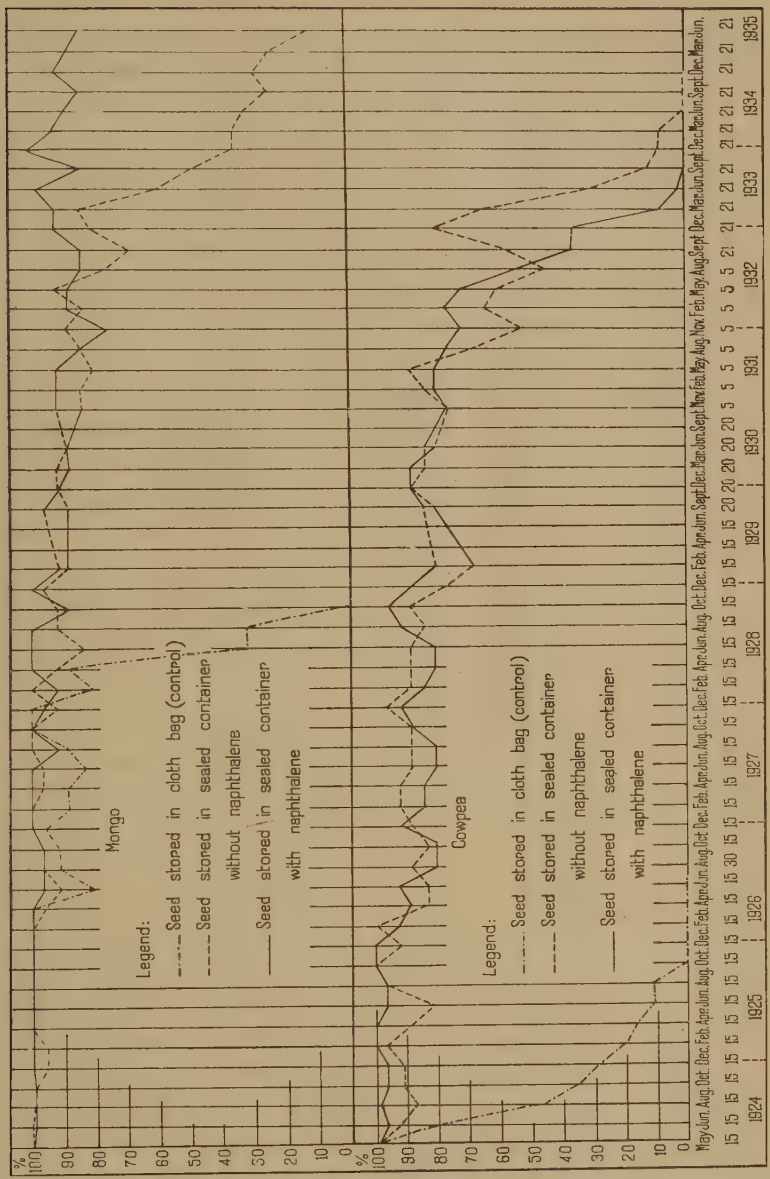

CHART 3. Showing the march of germination of mungo and cowpea stored under three sets of condition.

variety) which was still showing some signs of weak viability at this writing, showed life duration varying from 19 to 21 months for rice, 8 to 20 months for corn, 18.7 months for soybean, 16.5 months for peanut, 26.7 months for tapilan (white variety), and 57 months for mungo. The seeds in the sealed

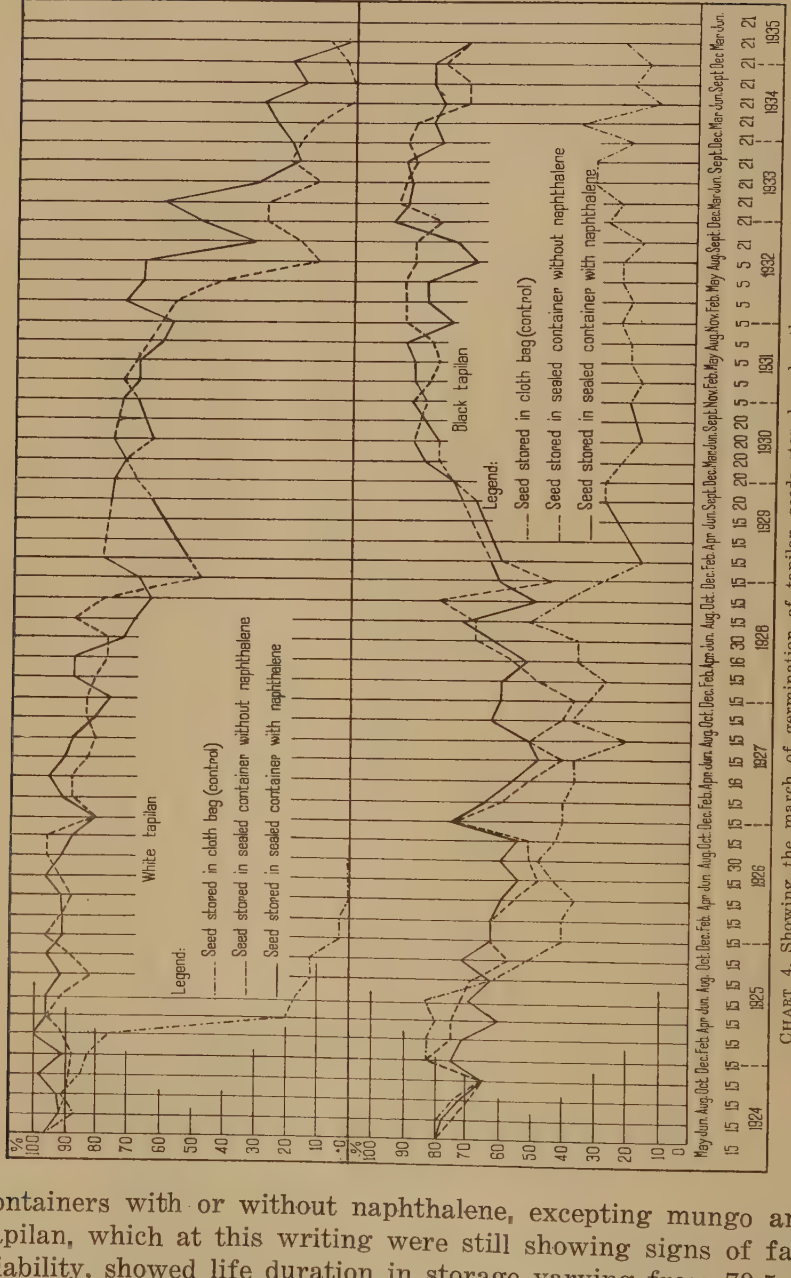

CHART 4. Showing the march of germination of tapilan seeds stored under three sets of condition.

containers with or without naphthalene, excepting mungo and tapilan, which at this writing were still showing signs of fair viability, showed life duration in storage varying from 79.5 to 85.5 months for rice, 63 to 82.5 months for corn, 54 months for

soybean, 36.5 months for peanut, and 114 to 123 months for cowpea.

Where the seeds were stored with naphthalene (see Tables 2, 3 and 4) some slight ill-effect on the longevity of the seeds was noticeable. This ill-effect, however, seemed to have been apparent only after the seeds have shown some signs of being critical. In rice and corn, there was a slight difference in the duration of life of the seeds stored in sealed containers with or without naphthalene in favor of the untreated seeds. However, in the case of cowpea and Australian Yellow Dent, a soft and starchy variety of corn, the seeds stored without naphthalene outlived those with naphthalene by over 9 and 20 months, respectively. In the case of mungo and tapilan, on the other hand, no apparent effect of napthalene has so far been noticed.

The result of this study should be of great help to the farmers and seed dealers since they can store their seeds better and for longer periods as air-dry seeds with the use of sealed or air-tight containers. The result has also a very important bearing on the preservation of valuable seeds for scientific investigation. It makes possible the storing of seeds in quantities for longer or shorter periods, thus keeping the purity of selected strains or varieties particularly those which are given out for propagation and for commercial planting. Plant breeders who are testing a large number of varieties and strains, under limited means, can take advantage of the result reported in this paper in that they can store part of their materials to be tested gradually in later years.

Empty petroleum cans make handy containers; they can be piled neatly and they can be shipped easily. Such containers can be sealed with paraffin or sealing wax, preferably the latter as the former is liable to melt when exposed for some time in the sun.

There is a very interesting phenomenon brought out in this study which as far as the writer has been able to ascertain with available literature has not yet been reported before. The graph on the march of germination of black tapilan (see graph No. 4) showed in a striking way that there was a rise in the percentage of germination after it had shown some signs of being critical from the fifty-fifth to the sixty-ninth months in storage as already reported (1929). It will be noticed in table 4 that the seed in the sealed containers with or without naphthalene gave a percentage of germination ranging from 44 to 80 with an average of 64.8 from the fifty-fifth to the sixty-ninth month in

storage. However, from the seventy-second month to December 21, 1934, 129 months after storage, the seed showed a strikingly stronger viability than in the previous months. The percentage of germination during this period ranged from 68 to 96 with an average of 84.7 for that in sealed container with naphthalene, and from 72 to 96 with an average of 85.5 for that without naphthalene.

The above facts made the writer reëxamine the germination performances of the other seeds under study. The data on the other legumes like mungo, cowpea, and white tapilan exhibited the same phenomenon of renewed vigor of viability after some indications of being critical have been recorded although in a lesser degree. The same manifestation could hardly be noticed in the case of starchy seeds like rice and corn. But even here, it could not be said with certainty that the same phenomenon was not exhibited. Perhaps, because of the rather long intervals between the dates of testing the seeds, the true course of the viability was not shown.

According to Crocker (1916), "some seeds capable of immediate germination can be thrown into a secondary dormancy by a period in a germinator lacking one condition necessary for germination or involving a substance inhibiting germination or one hardening the colloids of the coats." Of course, with more age, hardening the colloids of the coats is liable to happen, but this theory cannot hold true in the present case because of the fact that older seeds of the same kind were capable of better germination without any further treatment. It appears that this renewed life activity after a period of semi-dormancy without any change of treatment as shown by the black tapilan seed is a natural phenomenon manifested in many other ways in the life of both plants and animals.

SUMMARY OF CONCLUSIONS

This paper presents partial results of an eleven-year study on the longevity of some farm crop seeds kept under three different methods of storage. Two varieties of rice, three of corn, one each of cowpea and mungo, and two of tapilan were the subjects of this study.

Seeds stored in sealed or air-tight containers remained viable for a very much longer period than those stored in cloth bags or non-air-tight containers where the seeds were affected by the relative humidity of the air.

Seeds in sealed containers like legumes were capable of showing renewed vigor of viability after they had shown signs of being critical. The phenomenon was well illustrated in the case of black tapilan, a variety of *Phaseolus calcaratus*. This seems to be a natural phenomenon manifested in other ways in the life of plants and animals.

The legume seeds with the exception of the oily ones like soybean and peanut had longer spans of life than cereal seeds.

The life duration of the seeds in the air-tight containers varied with the kind of seed, e. g., 79.5 to 85.5 months for rice, 63 to 82.5 months, for corn, 114 to 123 months for cowpea, 54 months for soybean, 36.5 months for peanut, and over 135 months for mungo and tapilan. Mungo and tapilan seeds in sealed containers with or without naphthalene were still showing signs of fairly strong viability after 135 months (11 years and 3 months) in storage. The white variety of tapilan, however, was very critical at this period.

Naphthalene semed to have some ill-effect on the longevity of seeds in air-tight containers. In the case of rice, corn and cowpea which have already completely lost their viability, naphthalene seemed to have partially hastened the dying out of the seeds after they have shown some signs of being critical.

ACKNOWLEDGMENT

The writer wishes to express his sincere gratitude to Dr. Vicente C. Aldaba, Chief of the Fiber Research Section of this Bureau for his valuable suggestions and criticisms during the preparation of the manuscript.

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AGRICULTURAL ABSTRACTS

DORMANCY AND MATURITY OF COTTONSEED

By D. M. SIMPSON, Associate Agronomist, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

Experiments conducted at James Island, near Charleston, S. C. indicate that freshly opened cotton bolls contain a considerable percentage of dormant seed. This dormancy may be eliminated by drying and storing the seed for a short period. There was no appreciable difference in dormancy of fresh seed among several upland varieties; the sea-island strain tested showed practically no dormancy.

Studies of seed maturity indicated that cottonseed reaches maturity shortly before the bolls begin to open; at James Island, S. C., this period is from 40 to 50 days after flowering. (Adapted from the Journal of Agricultural Research, Vol. 50, No. 5, March 1, 1935, pp. 427–434.)

VIABILITY OF COTTONSEED AS AFFECTED BY FIELD CONDITIONS

By D. M. SIMPSON, Associate Agronomist and B. M. STONE, formerly Assistant Scientific Aid, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

The following summary is given:

Seasonal fluctuations in the germination of cottonseed have been attributed to climatic conditions during the harvesting season, but the definite relationship of rainfall, humidity and temperature to the viability of the seeds has received little attention. Experiments conducted at James Islands, S. C., in 1931, 1932 and 1933, under conditions of frequent rainfall and high humidity, provide information on these conditions.

Cotton harvested at James Island normally contains excessive moisture. Determinations of the moisture content of seed during the period of boll opening showed that seed from bolls just cracking open contained approximately 50 per cent moisture and that seed from partially opened bolls, which are ordinarily

harvested by the pickers, may contain more than 28 per cent moisture. Dry weather caused rapid reduction in the moisture content of the seed and seed cotton, but rainy, humid or cool weather prevented drying and delayed boll opening.

The low viability of seed harvested in unfavorable weather indicates that seed deterioration occurs in the field before harvesting. Seed from bolls just opening, when dried and stored for a short time, gave higher germination percentages than seed which had been exposed for longer period in the field.

Data on the viability of seed taken from bolls exposed for varying lengths of time in the field showed that deterioration of the seed was correlated with rains or humid conditions which prevented the prompt drying of the seed cotton after the bolls began to open. Seed from bolls opening and harvested during periods of dry weather gave higher germination percentages than did seed from bolls opening and harvested during rainy weather. Differences in resistance to field deterioration were apparent among the varieties tested, and the possibility of improvement in the germinating qualities of cottonseed by selective breeding is suggested. (Adapted from the Journal of Agricultural Research, Vol. 50, No. 5, March 1, 1935, pp. 435–447.)

RELATION OF MOISTURE CONTENT AND METHOD OF STORAGE TO DETERIORATION OF STORED COTTONSEED

By D. M. Simpson, Associate Agronomist, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

The following summary is given:

Storage experiments with sea-island and upland cottonseed under the humid conditions prevailing at James Island, S. C., showed that in ordinary storage, cottonseed deteriorates rapidly after 2 years. A definite relation is indicated between the moisture content of the seed during storage and the rapidity of deterioration. Sea-island seeds with a moisture content reduced below 8 per cent, when stored in tin containers to prevent rapid re-absorption of moisture, retained their germination percentage with only slight impairment for $4\frac{1}{2}$ years. Upland cottonseed stored under various conditions and containing from 8.75 to 13.78 per cent moisture deteriorated rapidly when the moisture in the stored seed remained above 10 per cent. Dried seed stored to prevent re-absorption of moisture showed only slight deterioration after $2\frac{1}{2}$ years. Seed containing 13.78 per cent

moisture and stored to prevent drying were all dead 9 months after the beginning of storage. (Adapted from the Journal of Agricultural Research, Vol. 50, No. 5, March 1, 1935, pp. 449–456.)

STUDIES IN GROWTH ANALYSIS OF THE COTTON PLANT UNDER IRRIGATION IN THE SUDAN: I. THE EFFECTS OF DIFFERENT COMBINATIONS OF NITROGEN APPLICATIONS AND WATER SUPPLY

By F. CROWTHER (Amm. Bot. [London] 48 (1934), No. 192, pp. 887–913)

Sakellaridis cotton grown at the Gezira Research Farm received light, medium and heavy irrigation and three levels of nitrogen (supplied by ammonium sulphate) in all possible combinations. The morphological and physiological processes resulting in the final crop were studied, and the measurements dealt with rates of change and growth curves rather than crop yield (E. S. R. 68, p. 38.)

Observations on numbers of flowers, numbers of nodes on the remaining stem, and on relative leaf-growth rates demonstrated the function of nitrogen in stimulating meristematic activity. The function of water in extension growth was shown by the internode lengths on the main stem, and it is suggested that its effect on flower numbers is indirect through regulation of extension growth. Net assimilation rate evidently is unaffected by water or nitrogen supply during the main growth phase.

The bolls appeared to exert a dominating effect on the whole plant when their development begins, resulting in the cessation of apical growth of the main stem and in the stoppage of nitrogen uptake from the soil, presumably through the checking of root growth. The nitrogen supply of the plant as a whole is interrupted at the time of the most serious drain on the plants' nitrogen reserved by developing bolls. It is suggested that the cessation of root growth operates through interference with the carbohydrate supply to the roots. The type of interaction between the factors was such that the increase in response to either factor increased with a higher level of the other. The practical importance of the results, particularly as to the necessity of obtaining early favorable growth is stressed. (Adapted from Experiment Station Record, Vol. 72, No. 5, May, 1935, p. 610, U. S. D. A.)

CIGARETTE AND CIGAR TOBACCOS; RELATIONSHIP OF PRODUCTION CONDITIONS TO CHEMICAL AND PHYSICAL CHARACTERISTICS

By W. W. Garner, C. W. Bacon and J. D. Bowling, Jr. (Indus. and Engin. Chem. 26 (1934) No. 9, pp. 970–974)

The chemical composition and the more important physical properties of flue-cured and Maryland cigarette tobaccos and Connecticut broadleaf binder and Pennsylvania seed leaf filler cigar tobaccos are presented, and their relationship to cultural methods and conditions are considered in this contribution from the U. S. D. A. Bureau of Plant Industry. The data were obtained in part in coöperation with the Maryland and North Carolina Experiment Stations and the North Carolina Department of Agriculture.

The marked difference in quantity of fertilizer nitrogen applied to the cigarette and the cigar types constitutes, according to the data presented, a highly significant factor in the sharp contrasts existing between these two classes of tobacco in the nitrogen-carbohydrate ratio and associated differences in composition of leaf. Certain commercial important distinctions in properties or qualities in the two classes of leaf, including color, elasticity, grain development, aroma, and in part combustibility, are correlated with these differences in chemical composition.

The difference in soil types and details of culture employed in growing the crop are important factors in the less pronounced contrast in properties existing between the cigar binder and cigar filler types, both high nitrogen products. In this instance contrasts in properties are not so clearly reflected in the organic constituents of the leaf, although significant differences exist in the composition of the ash. Both of the cigarette tobaccos have a high content of total carbohydrate, but the reason the Maryland type has an especially high content of pectin and cellulose instead of the high content of sugar and starch found in the flue-cured was not determined, although apparently soil factor is involved. The method of curing commonly used materially influences the chemical and physical characteristics of the flue-cured type. (Adapted from Experiment Station Record, Vol. 72, No. 5, May, 1935, p. 613, United States Department of Agriculture.)

STRUCTURAL RESPONSES TO THE PRACTICE OF TOPPING TOBACCO PLANTS: A STUDY OF CELL SIZE, CELL NUMBER, LEAF SIZE, AND VEINAGE OF LEAVES AT DIFFERENT LEVELS ON THE STALK

By G. S. AVERY, Jr. (Bot. Gaz. 96 [1934], No. 2, pp. 314–329.)

In the tobacco plant vegetative growth usually ceases soon after seeds start to form, but if the terminal flower stalk and all auxillary branches are removed by topping and suckering, respectively, as fast as they appear, the upper few leaves on the stalk continue to enlarge for some time. In a study with several varieties at Connecticut College, actually the upper third of the leaves on the stalk had a prolonged growth period in plants topped at the 21st leaf; and the 17th, 19th and 21st leaves of such plants, compared with corresponding leaves of untopped plants, showed 32 per cent greater average area and 29 per cent greater average thickness. This increased growth of upper leaves of topped plants appeared due to a greater than usual increase in cell size. The palisade and upper and lower epidermal cells averaged 31 per cent larger, whereas the fundamental tissue of the petiole did not increase in proportion to the blade tissues, its cells averaging only 23 per cent larger. The only change in numbers of cells (in leaves 17, 19, 21) due to topping seemed to occur in the vascular tissue. Cambial activity resulted in an average of 47 per cent more liquified zylem elements in the petiolar bundle. Differentiation of secondary pholoem in the petiolar bundles of these leaves was negligible despite cambial activity. In the upper leaves of topped plants fewer secondary pholoem cells were noted in the petiolar bundles than in corresponding leaves of untopped plants. The degree of development of the xylem and the amount of water loss were closely interdependent. See also an earlier note (E. S. R., 70, p. 614.) (Adapted from Experiment Station Record, Vol. 72, No. 5, May, 1935, pp. 613–614, United States Department of Agriculture.

ETHYLENE TREATMENT OF TOBACCO

By U. Rossi (Bol. Tec. [R. 1st. Sper, Coltiv. Tabacchi, Scafati], 30 (1933), No. 4, pp. 221–258; Fr. abs., pp. 257–258.)

Satisfactory results are reported from preliminary experiments wherein green leaves and whole plants and several varieties of tobacco were subjected under certain transformations occurring in the leaves during fire or air curing, and reduced the curing period about 40 per cent. Ethylene seemed to stimulate enzymatic reactions by irritation of cellular plasma without changing the characteristic qualities of the tobacco. Aroma, color and burn were improved, while elasticity was not affected. Ethylene treatment seemed to be useful with tobaccos hard to mature, slow ripening top leaves of certain oriental varieties, and tobacco poor in burn and aroma. (Adapted from Experiment Station Record, Vol. 72, No. 5, May, 1935, p. 614, U. S. D. A.)